CHAPTER 1

Basic Techniques in Laparoscopic Surgery

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Techniques in laparoscopic surgery have evolved greatly over the past several years. Presently, only the surgeon's imagination and the industry's willingness to produce innovative equipment limit the future development of new laparoscopic equipment. In this chapter, state-of-the-art methods for insufflation, access, dissection, hemostasis, retraction, tissue retrieval, robotic camera assistance, and intraoperative imaging are presented. The goal of the chapter is to increase the surgeon's repertoire of techniques in order to condense the learning curve, shorten procedure times, and improve patient outcomes. The final section in this chapter describes the indications and technique of retroperitoneal access. Separate chapters in this atlas are dedicated to reconstruction (including suturing and stapling), closure of the abdomen, and complications.

INSUFFLATION

Inspect the insufflator before the start of the case to ensure proper function, and check the CO_2 cylinder to ensure an adequate quantity of gas. From experience I have found that if there is insufficient CO_2 to complete the procedure, it will usually run empty at the most crucial part of the operation. Circulating nurses in the operating room must be familiar with the procedure of changing the CO_2 tank, and a spare tank must be available in the room at the start of the procedure. Attach sterile tubing at the beginning of the case, and check the pressure-flow mechanism by turning the gas flow to high and occluding the tubing. A rapid increase in pressure, above the preset limit, should cause flow of gas to cease. Then set initial pressure on the machine at 15 to 20 mm Hg.

PNEUMOPERITONEUM

It is my practice to create a pneumoperitoneum with the Veress needle before placing the first trocar. This simple technique is essentially unchanged since 1991 and is applicable to almost every laparoscopic situation. The pneumoperitoneum is accomplished by blindly passing the Veress needle into the peritoneum. The retracting tip and small size of the Veress needle help to minimize the risk of injury to underlying structures (Fig. 1–1).

In those patients without prior abdominal midline incisions, the umbilicus is a good site for initial entry with the Veress needle and the first trocar. At the umbilicus, the fascial layers fuse together allowing rapid entry into the peritoneum, the peritoneum is closer to the skin, and the incision is well concealed in this region (Fig. 1–2). Place a stay suture, if needed, at the site of initial entry to help elevate the abdominal wall and secure the trocar once in place. Holding the Veress needle like a dart, pass the tip perpendicular to the abdominal wall. Typically, two distinct layers are passed with the needle and then the blunt core pops forward: the first layer is the fascia, and the second is the peritoneum.

When the needle has advanced into the peritoneum, attach a 10-mL syringe containing 5 mL of normal saline to the needle. First, perform aspiration to detect any return of blood or bowel contents, which would require removal of the needle, replacement at a different site, and careful inspection of the underlying structures once the laparoscope is introduced into the abdomen. After aspiration, pass at least 5 mL of saline into the abdominal cavity, and attempt aspiration again. If the peritoneal cavity has been entered, saline usually will not return to the syringe with aspiration. If there is a return of saline, the needle is usually in the preperitoneal space and must be repositioned before attempting insufflation. Finally, after removing the syringe from the Veress needle, a small amount of saline will be seen in the hub of the needle where it was connected to the syringe. Correct placement of the needle allows any fluid left in the needle to fall into the abdomen once the syringe is disconnected.

Once the needle placement has passed all of these tests, attach the insufflation tubing to the needle and initially set the flow of gas at 1 L/min. The initial patient pressure needs to be less than 10 mm Hg, with the needle in the peritoneal cavity and the insufflator set on low flow. Higher pressures may indicate improper placement of the needle or occlusion of the tip of the needle against the bowel wall. If the pressure is greater than 10 mm Hg, elevate the abdominal wall and turn or retract the needle. If an elevated pressure reading persists, withdraw the needle immediately (before 150 mL of gas has been instilled). It will be necessary to pass the needle again, repeating all of the prior steps. If even a moderate amount of CO_2 gas is instilled in the preperitoneal space, it will be very difficult to gain access and have the trocar in the correct position during the procedure. If it appears that the needle was preperitoneal, the surgeon needs to move away from the initial site for repeat attempts at placement of the Veress needle.

As the peritoneal cavity fills with gas, there should be symmetrical expansion and loss of the dullness to percussion replaced with tympani. If there is asymmetric distention of the abdomen, the needle is probably not in correct position and a

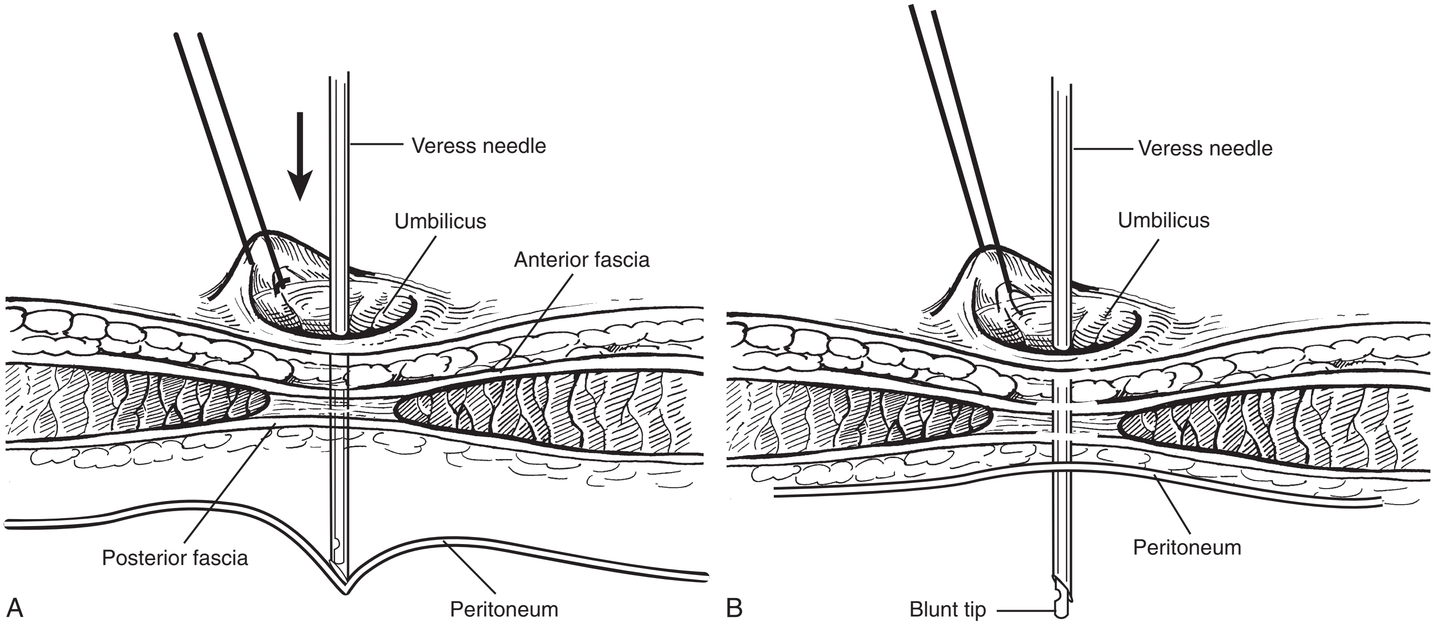


FIGURE 1–1. *A,* The blunt tip of the Veress needle retracts as it comes in contact with the skin, allowing the sharp needle to penetrate skin, fascia, and peritoneum. *B,* When the needle enters the empty space of the abdominal cavity, the blunt tip springs forward protecting underlying abdominal structures from injury. The sound of the blunt tip springing forward helps alert the surgeon that the abdominal cavity has been entered.

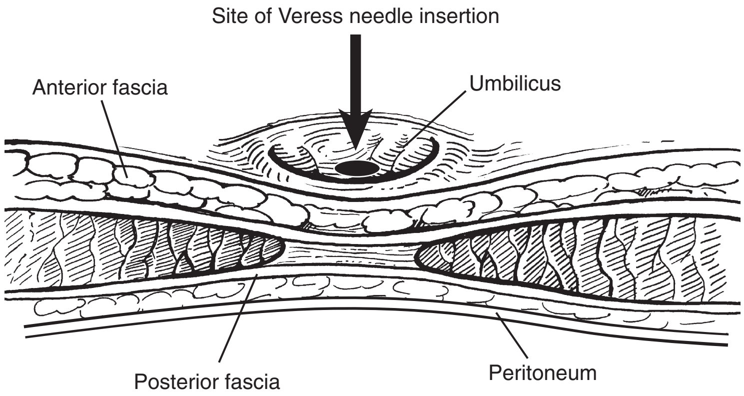


FIGURE 1–2. In patients without prior abdominal surgery through a midline incision, the umbilicus is an excellent site of entry. The incision is well concealed and the peritoneum is close to the skin.

new site, some distance away from the first site, needs to be chosen for needle placement (Fig. 1–3).

After instilling 1 to 1.5 L of gas into the abdomen and not detecting elevated pressures, turn the flow from the insufflator to high, even though the maximum flow through a Veress needle is less than 3 L/min. Approximately 4 to 6 L of gas will be required to completely distend the abdomen to a pressure of 15 to 20 mm Hg.

In patients with a history of abdominal surgery, pass the Veress needle and initial trocar at a site far from the previous incision sites. Avoid insertion over the liver, spleen, and left lower quadrant (where adhesion may be present from episodes of diverticulitis) if possible (Fig. 1–4).

CO_2 is the gas most commonly used for insufflation during laparoscopic surgery. It has the properties of high blood solubility and rapid absorption and does not support combustion. Although CO_2 is absorbed in the blood, it is removed in the lung during exhalation. A fatal intravascular dose of CO_2 in animals is five times greater than a fatal dose of room air (25 mL/kg CO_2 versus 5 mL/kg air).[1] Sudden cardiovascular collapse during laparoscopy may be secondary to gas embolism from needle placement into a blood vessel or highly vascular organ. Once a large volume of air enters the vascular system, the gas can accumulate in the right ventricle, obstructing the pulmonary blood flow and leading to cardiovascular collapse. The treatment is to immediately decompress the peritoneum and place the patient into the right-side-up, left-side-down, head-down position (Durant position). This position allows the gas to rise and blood flow through the right heart to continue (Fig. 1–5). In addition, start ventilation with 100% oxygen.

An initial insufflation pressure of 20 mm Hg creates a full and tense abdomen, facilitating trocar placement. This pressure is also helpful in maintaining an adequate pneumoperitoneum and working space because gas will escape during the procedure through and around trocar sites. Often, the obese patient requires a working pressure of 20 mm Hg during the entire case. In other patients, the pressure can usually be decreased to 10 to 15 mm Hg for the duration of the case. I try to work at the lowest pressure possible, given the

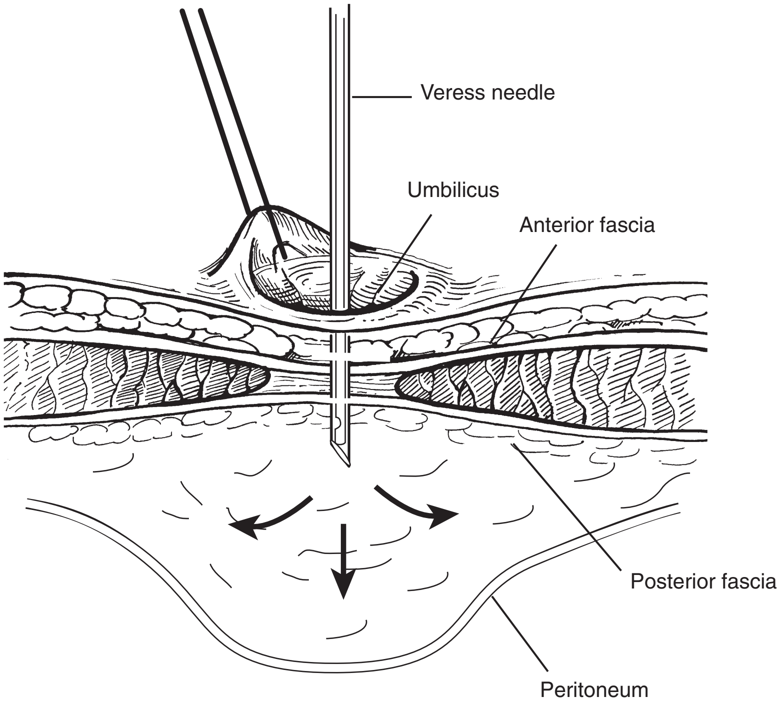


FIGURE 1–3. As the abdominal cavity fills with gas there should be symmetrical expansion and loss of the dullness to percussion. If there is asymmetric distension of the abdomen, the needle may be in the preperitoneal space. A different site, away from the first, should be chosen for needle placement.

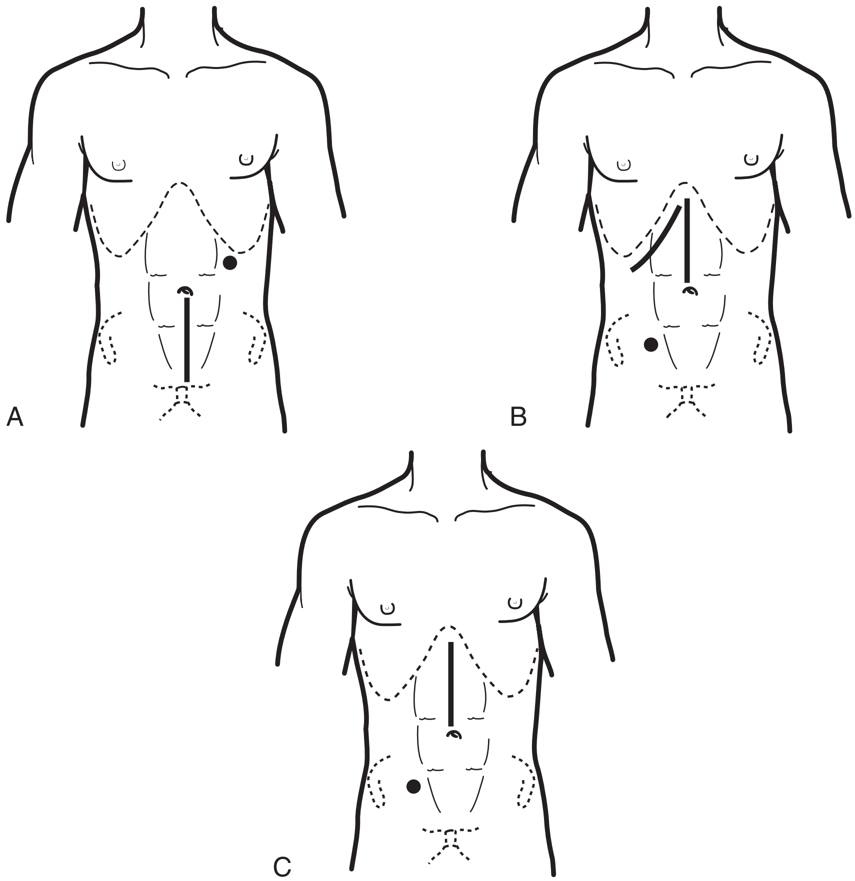


FIGURE 1–4. Sites of Veress needle placement for insufflation and initial trocar placement in patients who have undergone prior abdominal surgery.

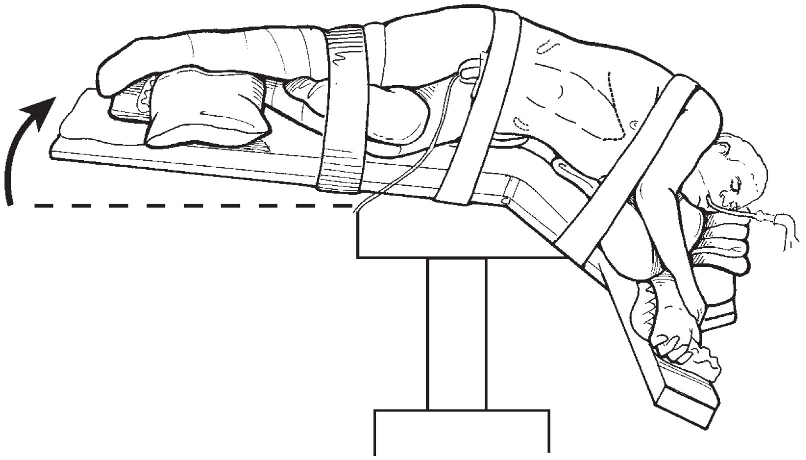


FIGURE 1–5. Sudden cardiovascular collapse from a pulmonary gas embolism is treated by immediate decompression of the pneumoperitoneum and placement of the patient in the right-side-elevated, head-down position.

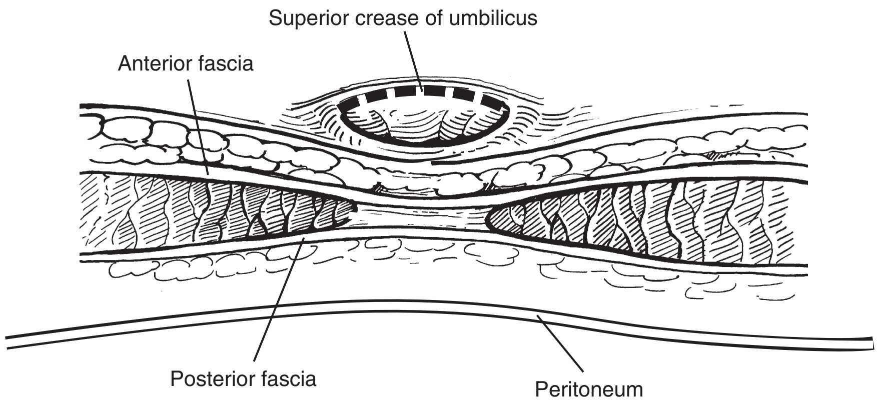


FIGURE 1–6. A curvilinear incision in the umbilicus is well concealed and offers excellent cosmesis.

patient's anatomy and the area of dissection, that will allow adequate visualization.

Adverse physiologic changes are seen at high abdominal pressures. As the intra-abdominal pressure is gradually increased above 25 mm Hg, there is decreased venous return to the heart. At pressures greater than 30 mm Hg, there is a decrease in cardiac output and hypotension may occur.[2]

The respiratory effects of pneumoperitoneum can be significant, particularly in patients with preexisting cardiopulmonary disease who manifest increased end-tidal CO_2, increased arterial CO_2, decreased arterial pH, higher peak airway pressure, and increased minute ventilation.[3] Increased ventilating volume and pressure may worsen the risk of barotrauma and pneumothorax in these patients. Healthy patients, on the other hand, demonstrate a mild increase in end-tidal CO_2 and arterial CO_2, a decrease in arterial pH, but no significant changes in peak airway pressure or minute volume[4] (see Chapter 3, Anesthetic Implications of Minimally Invasive Urologic Surgery).

TROCAR PLACEMENT

Primary Trocar

Site Selection

Place the first trocar in the same site as the Veress needle insertion for insufflation. In many cases, the umbilicus is the site of choice. A curvilinear incision made at the umbilicus after insufflation is well concealed and offers an excellent cosmetic result (Fig. 1–6). When patients are in complete lateral or a modified lateral position, a site lateral to the rectus muscle may be the best site for initial insufflation and trocar placement because bowel may have moved closer to the umbilicus. After placing the lateral trocar, place the remaining ports under direct visualization. During placement, direct all trocars slightly toward the area of surgical interest to allow decreased tension during dissection and to help prevent trocar site holes from being aligned. Staggering the access site from entry at a slight angle will decrease the chance for hernia formation (Fig. 1–7).

Visual Obturator

After insufflation, place the initial port under direct vision using a trocar with a visual obturator. When using a visual obturator, turn the light source to low, and place the laparoscope inside the visual obturator, focusing on the clear lens, and through the initial trocar sheath. With either gentle twisting motion or a trigger mechanism, divide the muscle and peritoneum under direct vision.

Several trocars with a visual obturator are currently available and allow access under direct vision. The 12-mm Visiport Plus RPF trocar (U.S. Surgical, Norwalk, CT) uses a recessed blade that extends out of the end of the obturator as the surgeon fires a trigger on the pistol grip (Fig. 1–8). The newly engineered Endopath Xcel trocar (Ethicon Endo-Surgery, Cincinnati, OH) and the Optical Separator (Applied Medical, Rancho

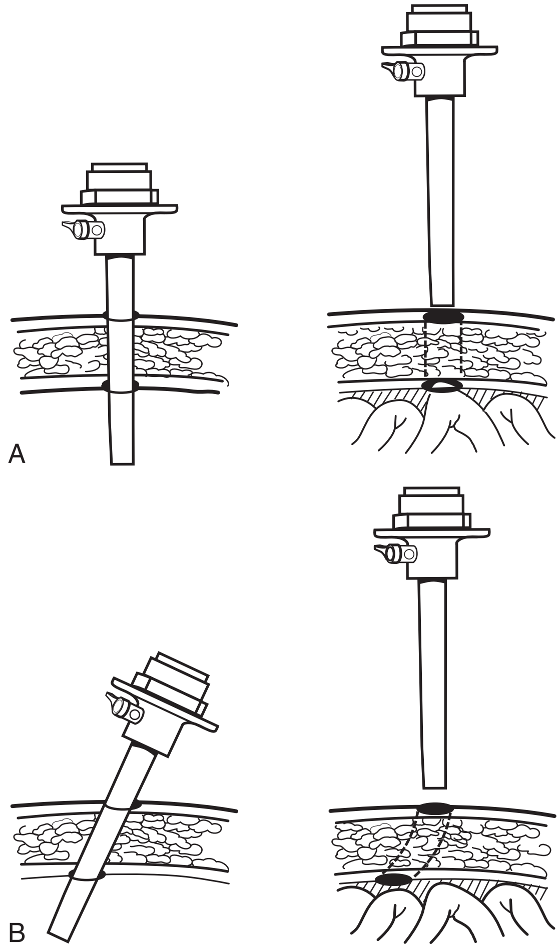


FIGURE 1–7. *A,* A trocar placed directly perpendicular to the fascia can allow the anterior and posterior fascial entry sites to line up after the trocar is removed and will be under tension during the dissection. *B,* A trocar placed at a slight angle directed toward the site of dissection will leave the anterior and posterior entry sites staggered and allow dissection with less tension on the skin.

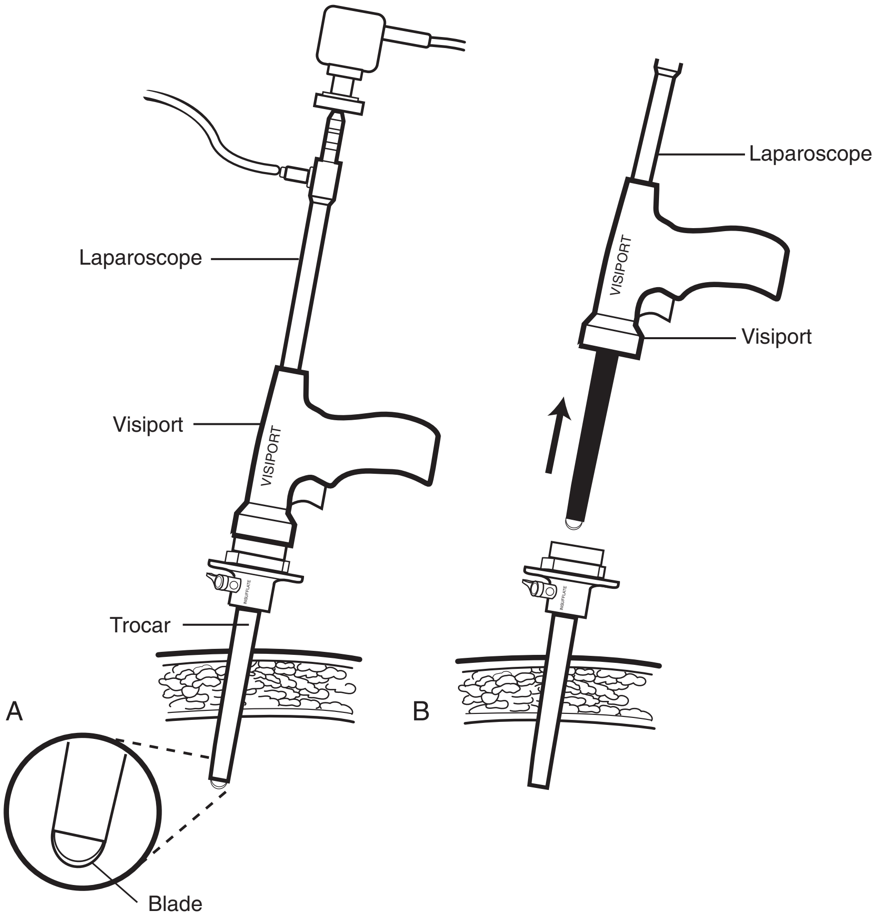


FIGURE 1–8. *A,* The Visiport Plus RPF trocar (U.S. Surgical, Norwalk, CT) uses a recessed blade that extends out of the end of the obturator as the surgeon fires a trigger to incise fascia, muscle, and peritoneum under direct vision. *B,* Once the trocar is in the abdominal cavity, the Visiport is removed.

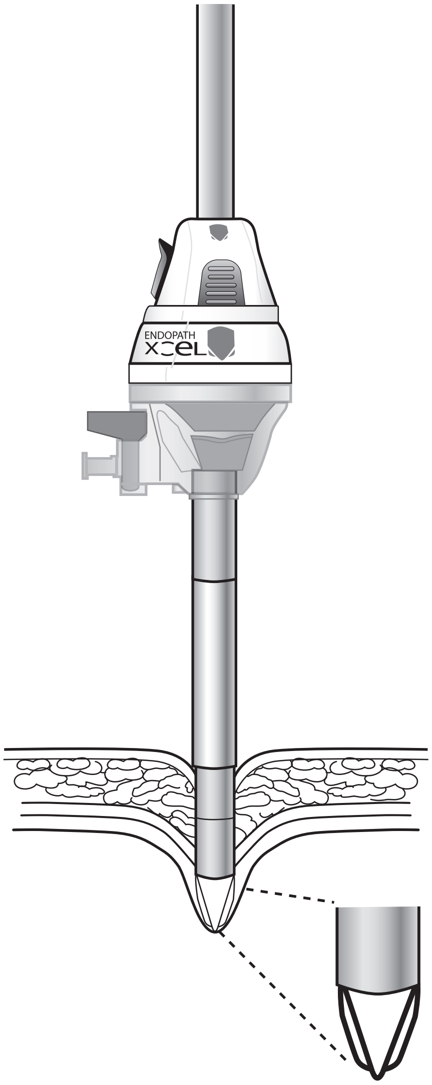


FIGURE 1–9. The Endopath Xcel trocar (Ethicon Endo-Surgery, Inc., Cincinnati, OH) system uses two sharpened blades on the tip of the trocar. A gentle twisting motion uses the blades to cut through the abdominal layers into the peritoneum under direct vision.

Santa Margarita, CA) 12-mm and 5-mm systems use two sharpened ridges (in different configurations) on the tip of the trocar to divide fascia and enter the peritoneum, while the surgeon watches via the laparoscope inserted through the center of the trocar (Fig. 1–9). These systems allow rapid entry under direct vision, with potentially less risk of injury compared with blind trocar insertion.

Hasson Cannula

The Hasson technique of initial port placement may be useful for patients with a history of extensive or multiple abdominal surgeries or peritonitis. The Hasson system consists of a trumpet valve with tying struts, cone-shaped sleeve, and blunt-tipped obturator. Make a 2- to 3-cm incision in the skin at the insertion site, sweep the preperitoneal fat off the fascia, and incise the fascia. Elevate the peritoneum with a pair of forceps and open it sharply. Confirm entry into the peritoneal cavity by looking directly or by passing the index finger into the peritoneal cavity. Place two 0 monofilament fascial stay sutures, and include the edge of the peritoneum. These sutures can be used at the end of the case to close the trocar site. Insert the Hasson system through the peritonotomy and push down the conical collar into the skin incision to occlude the opening, preventing escape of CO_2 during insufflation. The fascial sutures secure the trocar to the abdomen and help to keep the cone-shaped collar seated. Attach the insufflation tubing and create the pneumoperitoneum.

Place the AutoSuture Blunt Tip Trocar (U.S. Surgical, Norwalk, CT) in fashion similar to the traditional Hasson trocar, that is, through a small open incision. This trocar uses an inflated balloon on the inside and a locking foam collar on the skin to create an airtight seal. The cap allows use of 5-mm, 10-mm, and 12-mm instruments and has insufflation and desufflation ports. The low profile of the trocar makes it especially useful for working in the limited space of the retroperitoneum (Fig. 1–10).

Secondary Trocar

After placing the primary trocar, insert a laparoscope into the abdomen and perform a thorough survey, looking for any evidence of injury, adhesions, or unexpected pathology during Veress needle and primary trocar placement. Place all secondary trocars under direct vision. The exact position of trocar placement is dependent on the procedure being performed and experience with the laparoscopic procedure. Trocars that are placed too close together make it difficult to dissect in the abdomen and limit movement because handles and trocars collide.

Before placing a trocar, use a finger to indent the outside of the abdominal wall at the purposed trocar site. While looking from the purposed site to the area of dissection (using the view from inside the abdomen), make adjustments before committing to a particular site. Remove adhesions near proposed trocar sites before placing the trocar in order to avoid injury to the bowel during trocar placement or during closure. If desired, place a long spinal needle at the proposed trocar site into the abdomen as a so-called finder needle to further identify the exact location inside the abdomen. Recommended sites for trocar placement are carefully described and diagrammed in the chapters of this atlas for each specific procedure.

After determining the trocar site, direct the laparoscope so that the skin is transilluminated, identifying blood vessels and the rectus muscles to avoid during trocar placement. In particular, the large inferior epigastric vessels can usually be identified with transillumination and injury avoided.

Create a skin incision at the trocar site with a No. 11 blade, and use a hemostat to spread the subcutaneous tissue to the level of the fascia. Do not create an incision that is too large because this will result in continual escape of CO_2 during the procedure and may lead to subcutaneous emphysema, acidosis, or even a pneumothorax and pneumomediastinum due to communication with the subcutaneous space. Make the incision just large enough to allow the obturator and the trocar sheath to enter the skin. An incision that is too small will not allow the trocar under the skin and puts the underlying structures at risk for perforation because excess force is required to enter the abdomen and, if the trocar suddenly gives way during insertion, the trocar may not be able to be stopped and it may damage bowel, other organs, or major vessels.

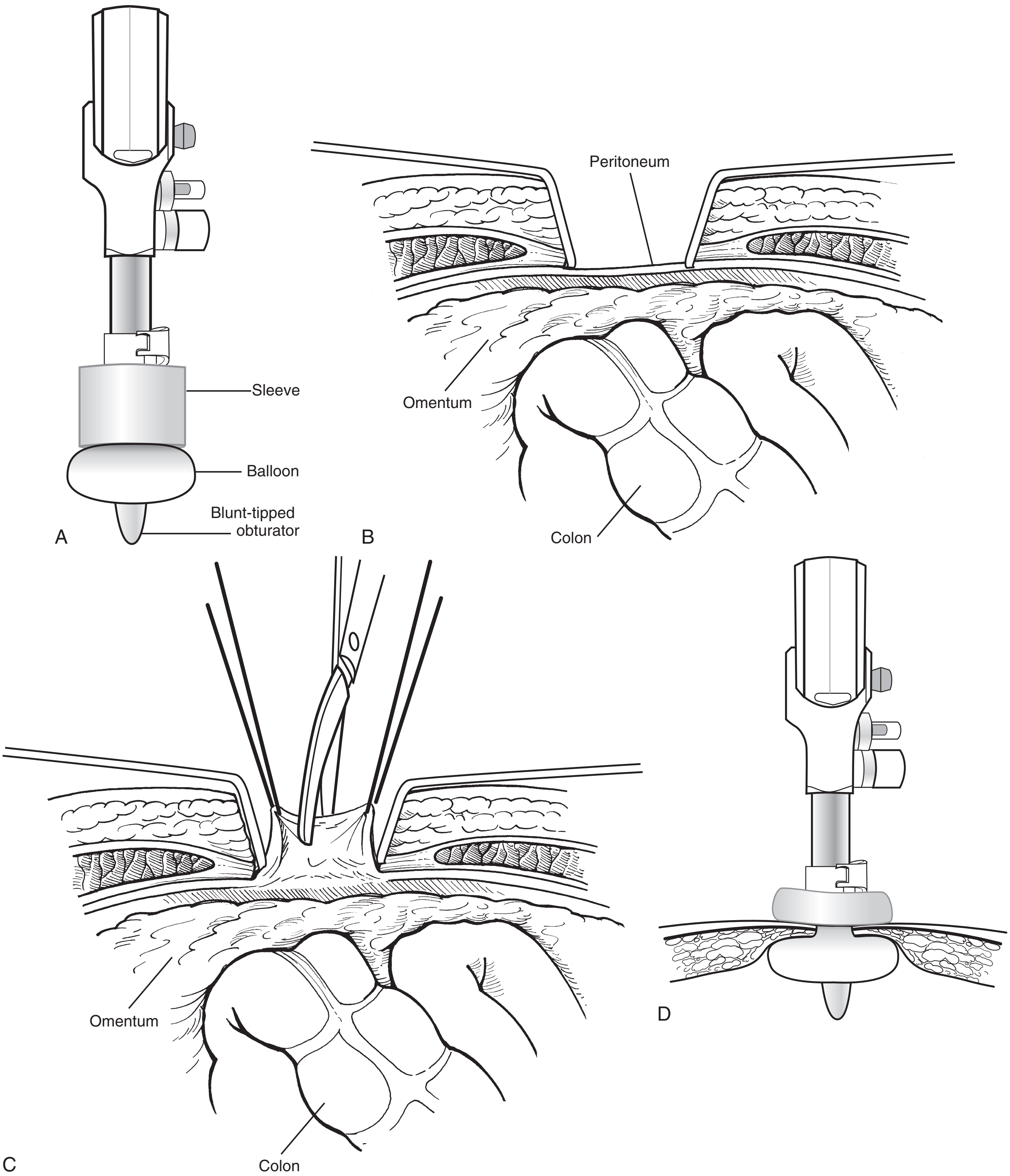


FIGURE 1–10. *A,* The Blunt Tip Trocar (U.S. Surgical) consists of a balloon inflated inside the working space and a locking foam sleeve that creates a gas tight seal. *B,* A 2- to 3-cm incision is made in the skin at the insertion site, the subcutaneous fat swept off the fascia, and the fascia incised. *C,* The peritoneum is elevated and opened sharply. Entry into the peritoneal cavity is confirmed with direct vision or by passing the index finger into the peritoneal cavity. *D,* The trocar is inserted into the cavity, the balloon filled with air, and the foam sleeve slid down onto the skin and locked in place to prevent escape of CO_2 during insufflation.

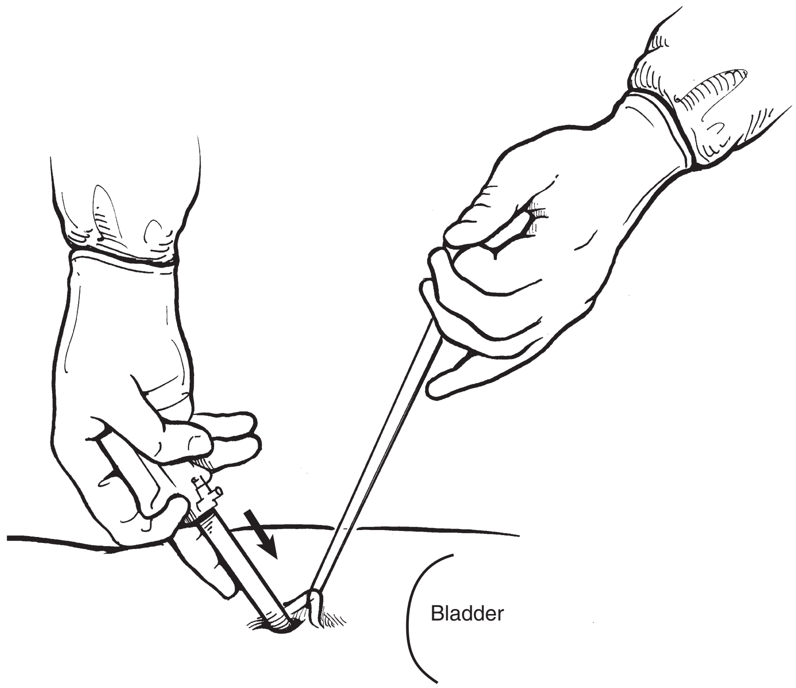


FIGURE 1–11. During trocar placement, grasping the skin or lifting the stay suture to apply counter traction elevates the abdominal wall. The surgeon holds the trocar firmly in the dominant hand, with one finger extended along the sheath to act as a brake. A gentle constant twisting motion will help the trocar advance.

During secondary trocar placement, move the insufflation port on the trocar to the closed position to prevent rapid escape of insufflate during placement. Grasp the trocar firmly in the dominant hand, with one finger extended along the sheath to act as brake. Use a gentle constant twisting motion slightly toward the area of dissection to help the trocar advance (Fig. 1–11). Carefully watch the tip of the trocar under direct vision with the laparoscope. Direct the trocar slightly toward the area of dissection while advancing into the peritoneal space (Fig. 1–12). If the trocar is advanced in a direction away from the site of dissection, there will be constant tension on the skin during the case, tension on instruments when not in use, and increased chance for gas to escape at the trocar site. Once the trocar is in place, position it so that approximately 1.5 cm of the trocar is inside the peritoneal cavity. Place a suture through the skin and wrap each strand around the insufflation port (Fig. 1–13) so that the trocar can easily be advanced if necessary and pulled back to the limit of the suture without being inadvertently pulled out of the abdomen during stapling or suturing (Fig. 1–14).

Occasionally, even an experienced surgeon creates a skin entry site that is too large for the trocar, allowing CO_2 to escape. Several steps can be taken to narrow the opening or prevent subcutaneous emphysema and loss of intra-abdominal pressure during the procedure. Try placing a skin suture or penetrating towel clamp to narrow the skin opening and stop gas escaping. In addition, try wrapping a gauze sponge coated with petroleum jelly around the trocar and pushing the sponge against the skin to seal the site.

Inspect all trocar sites for bleeding with the laparoscope after insertion. Persistent bleeding from a lateral trocar site or hematoma formation may indicate injury to the rectus muscle or laceration of the inferior epigastric vessels. Slow oozing from a site will usually stop shortly after port placement due to the tamponade effect of the trocar. Treat sites that have persistent bleeding with a figure-of-eight suture passed on a straight needle above and below the site and secured on the abdomen (Fig. 1–15).

DISSECTION

Safe dissection during laparoscopy requires knowledge of the characteristics and location of tissue planes. With blunt and sharp dissection, these planes can be exploited to expose the desired structures and organs with little trauma and minimal bleeding. Each laparoscopic surgeon has a preference regarding instruments used for dissection. Many use a combination of scissors with monopolar electrocautery, bipolar electrocautery, ultrasonic (US) energy, and blunt dissection with the tip of the irrigator aspirator. Others prefer to use a hook electrode. The tip of the irrigator aspirator is useful as a blunt instrument during dissection. The tissue can be trapped with the tip while applying suction and then spread in the opposite direction of a grasper to open a tissue plane; then the suction is discontinued and the tissue is released (Fig. 1–16).

HYDRODISSECTION

Waterjet cutting and hydrodissection continue to be areas of active investigation for lymph node dissection and partial nephrectomy. Hydrodissection is advanced technology using water at high pressure to act as a sharp instrument. In the past it has been used in delicate corneal surgery and cholecystectomy. In laparoscopic partial nephrectomy, a hydrojet generator (Muritz 1000; Euromed Medizintechnik, Schermwin, Germany) has been used to create a thin stream of water under great pressure (30 atm) that rapidly separates renal parenchyma while preserving vasculature, which can be coagulated and divided using conventional cautery.[5]

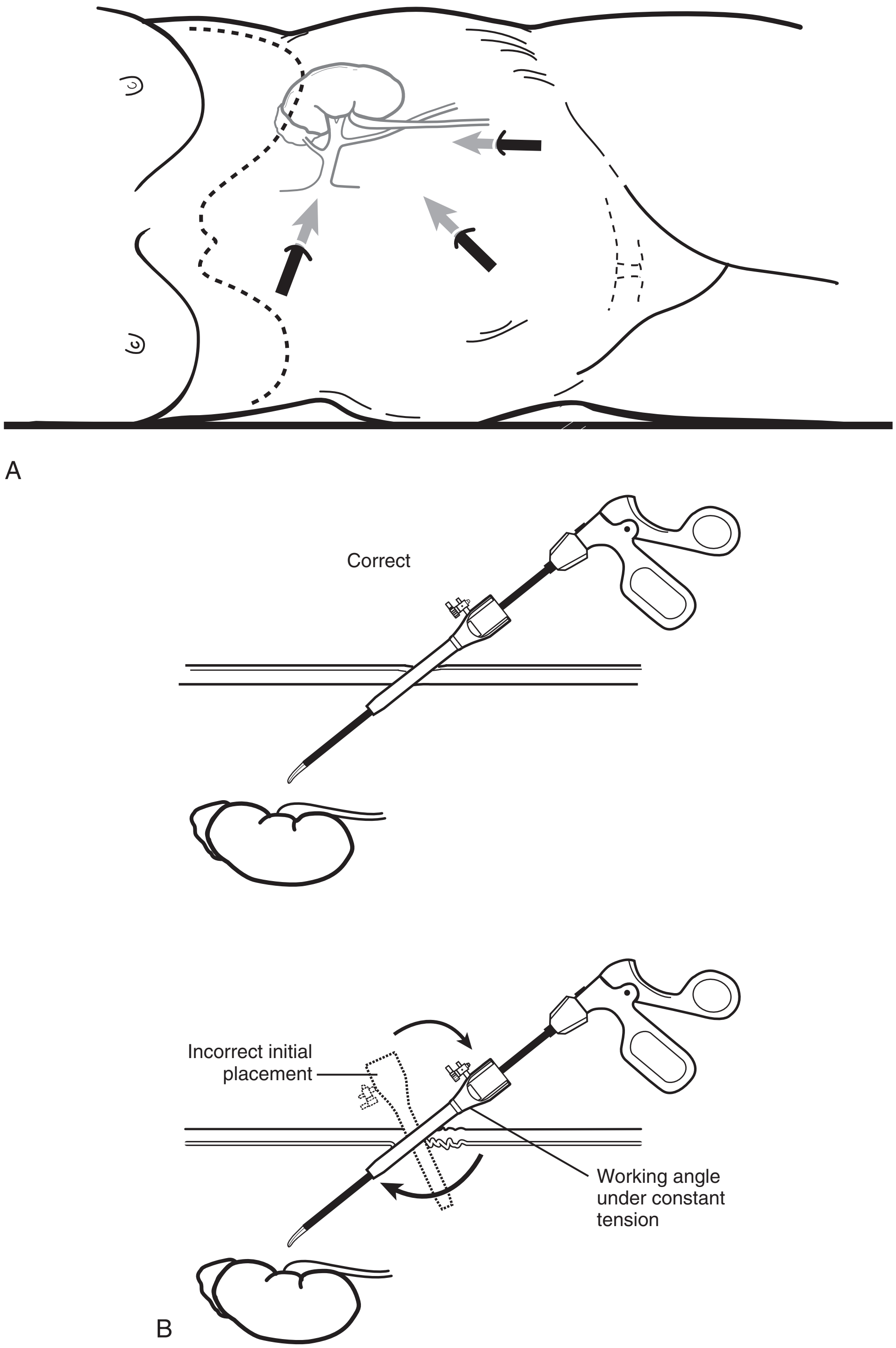


FIGURE 1–12. *A,* The trocar should be directed slightly toward the area of dissection as it is advanced into the abdominal cavity. *B,* Placement of the trocar at a correct angle allows dissection without tension on the instrument. If the trocar is inserted at an angle away from the site of dissection, there will be constant tension on the instrument and trocar.

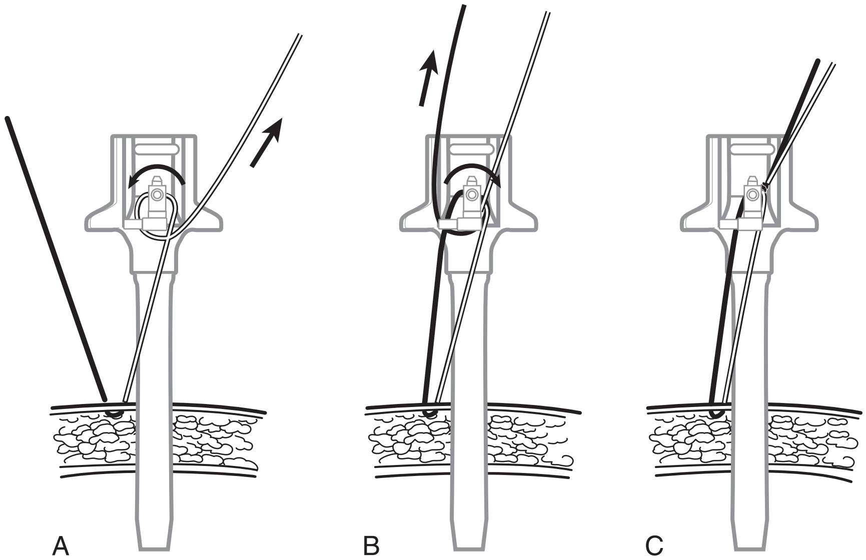


FIGURE 1–13. *A,* To secure the trocar, a suture is placed through the skin and one strand is wrapped around the inside of the gas valve. *B,* The second strand is wrapped inside the valve in the opposite direction. *C,* The two strands are tied, securing the trocar and preventing the suture from slipping from the trocar during the procedure.

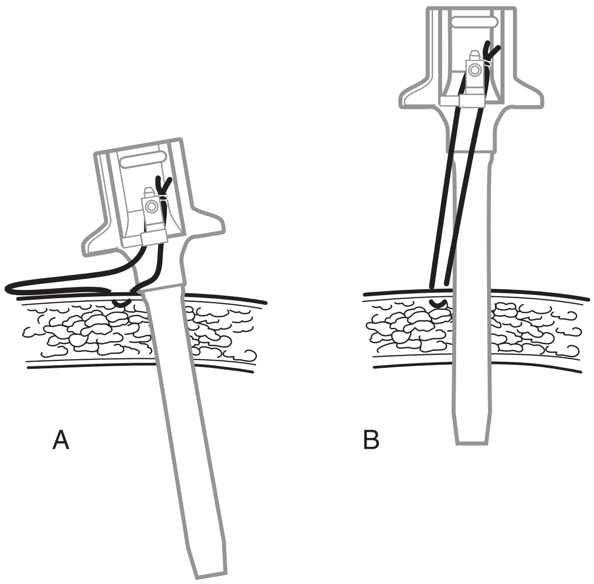


FIGURE 1–14. *A,* Once the port is secured it can easily be advanced if needed. *B,* The port can then be pulled back to the limit of the suture without being inadvertently pulled out of the abdomen or having the suture fall off of the valve.

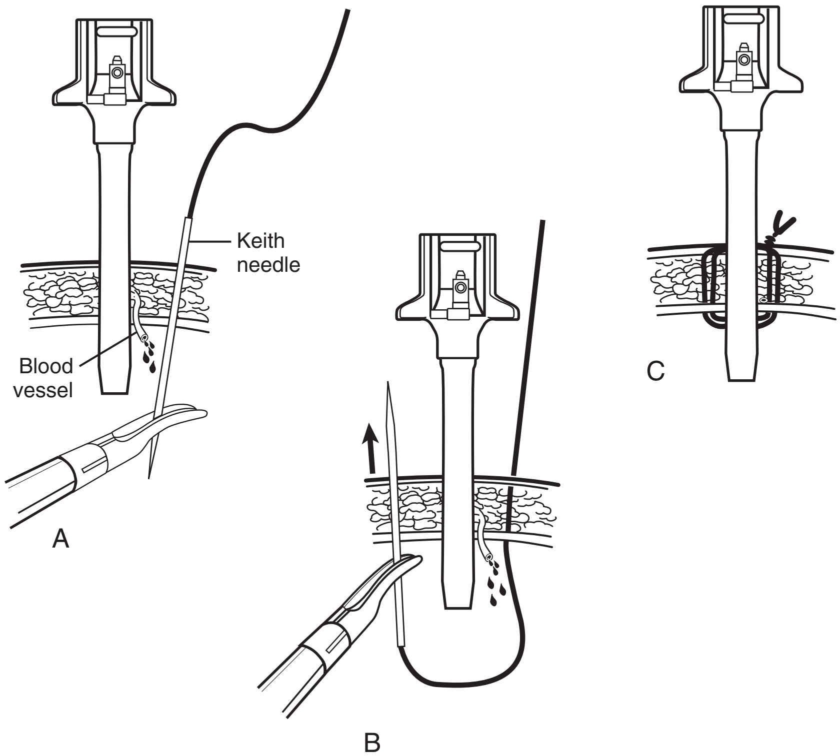


FIGURE 1–15. *A,* Slow oozing from a site will usually stop shortly after trocar placement due to the tamponade effect of the trocar. Sites that have persistent bleeding can be treated with two passes of a suture on a straight needle. *B,* The suture is passed through the fascia and skin on the opposite site of entry. *C,* After the second pass, the suture is tied on the skin.

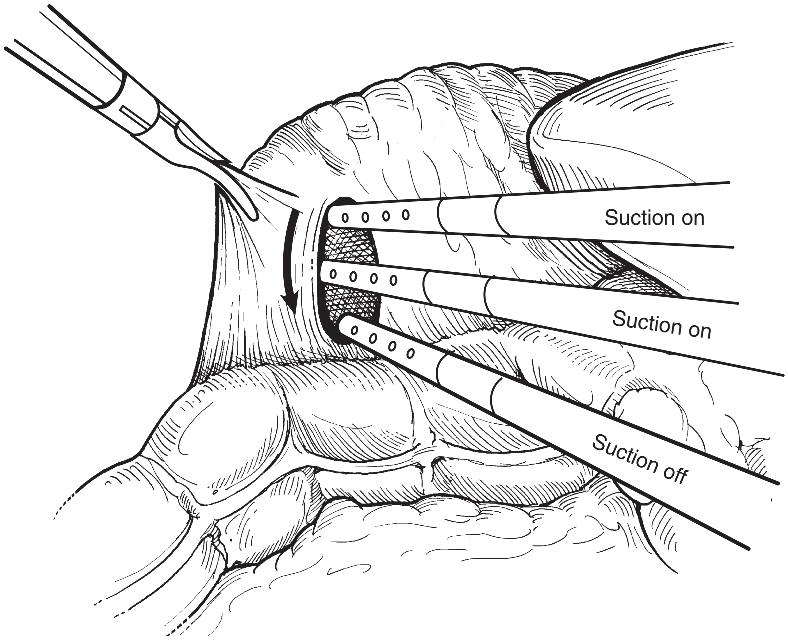


FIGURE 1–16. The irrigator aspirator is useful during dissection as a blunt instrument and aspirator. The tissue is trapped with the tip while suction is applied and then spread in the opposite direction of a second instrument. Once the tissue plane is opened, the suction is discontinued, releasing the tissue.

HEMOSTASIS

Electrocautery

Electrocautery was initially the mainstay for hemostasis during laparoscopic dissection, but it is slowly being replaced by other technologies. Nevertheless, an important role remains for electrocautery's safe use in laparoscopic surgery. Excessive bleeding from even small venous vessels can quickly obscure the surgical field, causing difficulty in finding correct planes of dissection. Surgery on retroperitoneal structures requires operating very close to bowel segments. In the retroperitoneal approach, bowel is not readily identified, but it is also in the area of dissection and subject to thermal injury. More than half of laparoscopic bowel injuries reported in the literature result from electrocautery insult. Thermal injury can be prevented by vigilant surveillance of contact points during dissection.[6]

Monopolar electrosurgery is the modality still commonly used in surgery. In the monopolar circuit, the active electrode is in the surgical site and the return electrode is the grounding pad. Consequently, the current passes through the body of the patient to complete the circuit (Fig. 1–17). The waveform can be continuous or intermittent (cut or coagulation) and is low current with high voltage. Avoid applying monopolar electricity to ductlike strands of tissue attached to bowel. A rise in temperature from electrocautery on these small bands from a short burst of energy can result is tissue death at the bowel segment.[7] Unrecognized bowel injuries can also occur because of stray energy released from breaks in the integrity of the insulated coating or capacitative coupling along the shaft of the instrument or trocar. These injuries can occur outside the surgeon's field of view[8] (Fig. 1–18).

The use of monopolar instruments and active electrode monitoring devices minimizes the chance of unrecognized thermal injury from insulation failure, direct coupling, and capacitative coupling. When an active electrode monitoring system (AEM active electrode monitoring system; Encision, Boulder, CO) detects stray energy, the electrosurgical generator is deactivated before injury can occur.

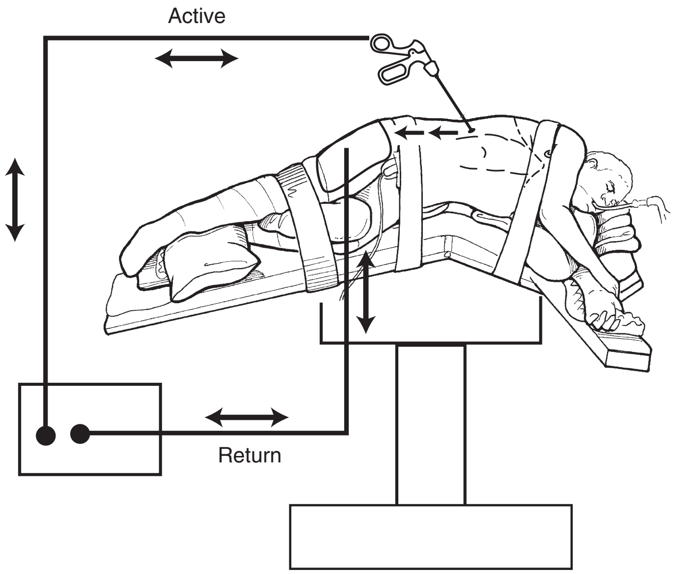


FIGURE 1–17. In a monopolar circuit the active electrode is in the surgical site and the return electrode is the grounding pad on the patient's skin. The current passes through the body of the patient to complete the circuit.

In bipolar electrosurgery, the active electrode and the return electrode functions are performed at the site of surgery between the tips of the instrument. The waveform is continuous, low current, and low voltage. Only the tissue grasped is included in the electrical circuit. The risk of injury from stray surgical energy is minimized with this system (Fig. 1–19).

Argon beam coagulation uses the properties of electrosurgery and a stream of argon gas to improve the effectiveness of the electrosurgical current. Argon gas is noncombustible and inert, making it a safe gas to use in the presence of electrosurgical current. The argon gas is ionized by the electrical current, making it more conductive than air. The highly conductive

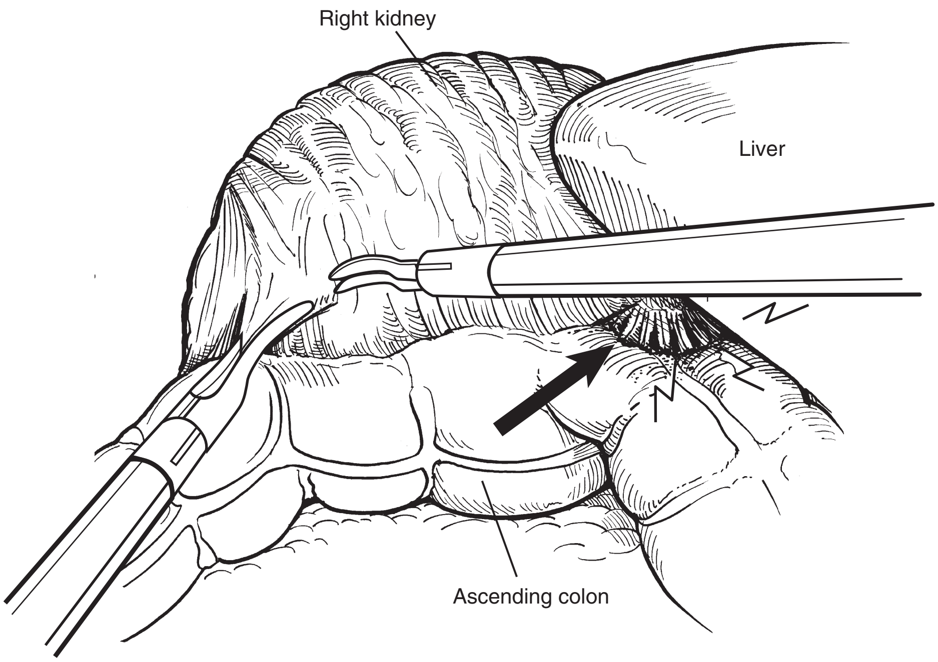


FIGURE 1–18. Injuries can occur out of the surgeon's field of view due to breaks in the integrity of the insulated coating and capacitive coupling along the shaft of the instrument.

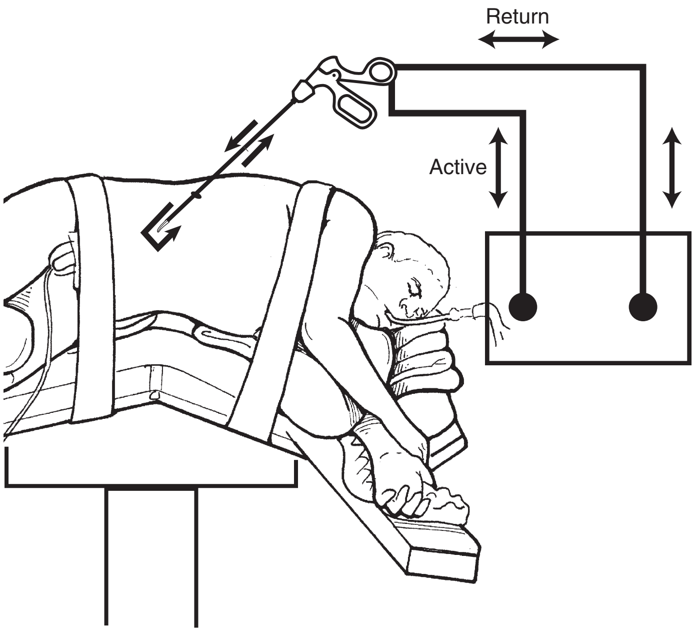


FIGURE 1–19. In a bipolar circuit, the active electrode and the return electrode functions are performed at the site of surgery between the tips of the instrument. Only the tissue grasped between the jaws of the instrument is included in the electrical circuit.

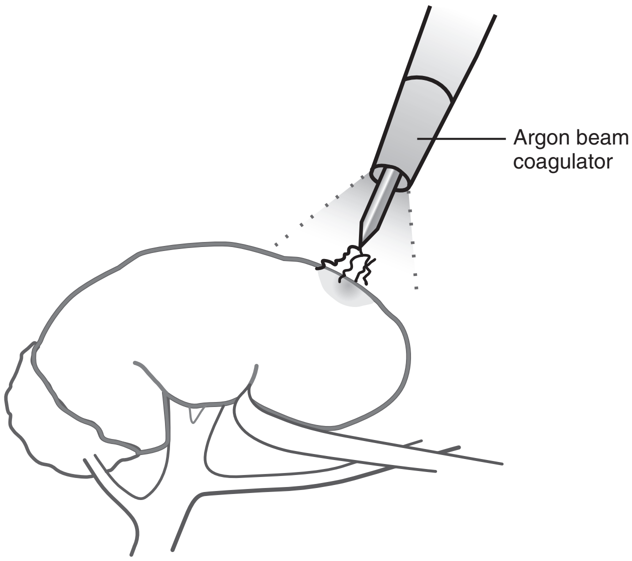


FIGURE 1–20. Argon beam coagulation uses the properties of electrosurgery and a stream of argon gas to improve the effectiveness of the current. The argon gas is ionized by the electrical current, making it more conductive than air.

stream of argon gas provides an efficient pathway for delivering the current to tissue, resulting in hemostasis. Because the laparoscopic argon beam coagulator does not have an evacuation system, the pressure inside the abdomen can rise quickly above the desired level. Consequently, an insufflation port should be opened during coagulation (Fig. 1–20).

Ultrasonic Technology

Laparoscopic dissection with excellent hemostasis can be accomplished using US energy to achieve precise cutting and coagulation. At least three different manufactures are currently marketing systems using US energy for hemostasis. All of the systems use a laparoscopic 5-mm or 10-mm handpiece with a shaft tuned to conduct the US vibration at the rate of approximately 55,000 cycles per second. The vibration

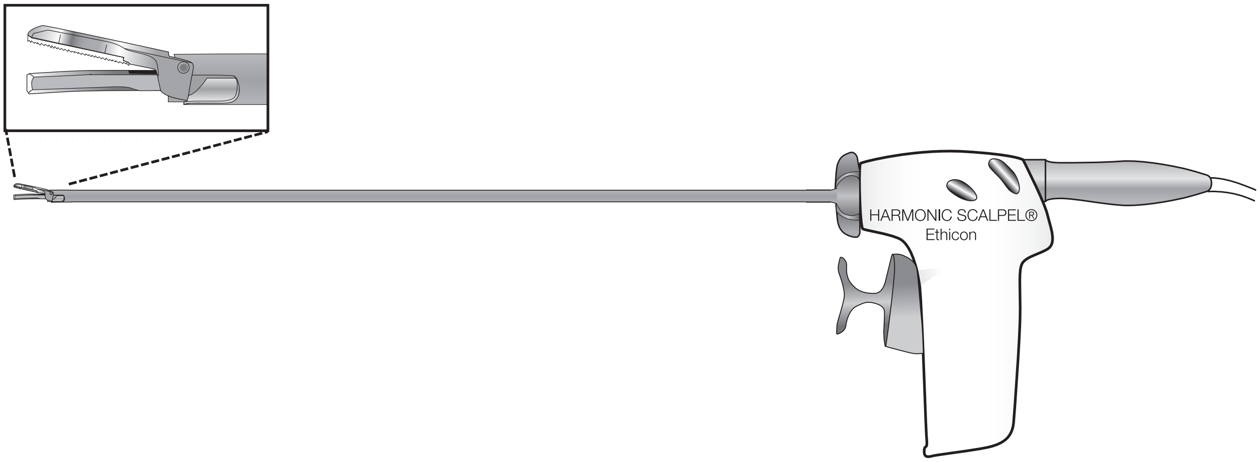


FIGURE 1–21. Three laparoscopic US dissection devices are currently available (the UltraCision Harmonic Scalpel, Ethicon Endo-Surgery, Cincinnati, OH; the AutoSonix System, U.S. Surgical, Norwalk, CT); and the SonoSurg, Olympus, Melville, NY. All systems use a laparoscopic 5-mm or 10-mm handpiece that has a shaft tuned to conduct the US vibration at the rate of approximately 55,000 times per second causing protein to denature. The result is hemostasis and tissue division at a temperature much lower than that of conventional electrocautery. Water vapor is emitted in the abdomen instead of smoke.

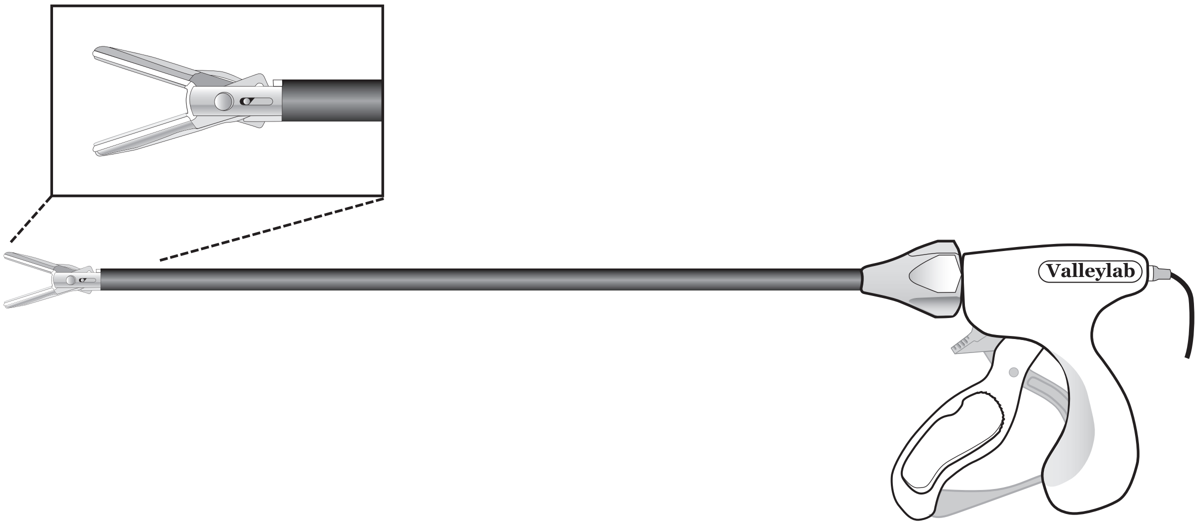


FIGURE 1–22. *A,* The LigaSure is a specialized electrosurgical generator/instrument system developed to reliably seal tissue and blood vessels up to 7 mm in diameter (Valleylab, Boulder, CO). The vessel lumen is obliterated as collagen and elastin in the vessel wall fuse to form a permanent seal. The seal zone must then be divided with standard laparoscopic scissors.

causes heat, which is more precisely located at the vibrating tip, and at 50°C to 100°C, this temperature is much lower than that of conventional electrocautery. Despite the lower temperatures, the tip, at 100°C, can cause thermal injury to vital structures if used for dissection immediately after use for coagulation.

Different tip configurations are available, including hooks, straight shears, curved shears, and blunt probes. As the tissue is compressed between the jaws of the shears, blood vessels are occluded and the vibration causes intracellular water vaporization. Proteins are denatured in the tissue, and protein coagulum forms, sealing blood vessels. Hemostasis and division of tissue occur at temperatures less than those of conventional cautery, without the wide dispersion of heat creating a small band of tissue necrosis. Water vapor is emitted in the abdomen instead of the smoke that is seen with electrocautery (Fig. 1–21). Current configurations include activation triggers on the handpiece and traditional foot pedals and reusable devices.

LigaSure System

A specialized electrosurgical generator/instrument system has been developed (LigaSure, Valleylab, Boulder, CO) to reliably seal tissue and blood vessels up to 7 mm in diameter during laparoscopic or open surgery. The generator delivers a continuous waveform of low-voltage, high-current flow and pulsed electrosurgical energy to tissue between the jaws of the instrument. The tissue is under a predetermined amount of pressure set by the unique jaws of the instrument. The vessel lumen is obliterated as collagen and elastin in the vessel wall fuse to form a permanent seal. Both 5-mm and 10-mm instruments have built-in cutting devices so that the sealed zone of tissue can be divided with a finger trigger (Fig. 1–22).

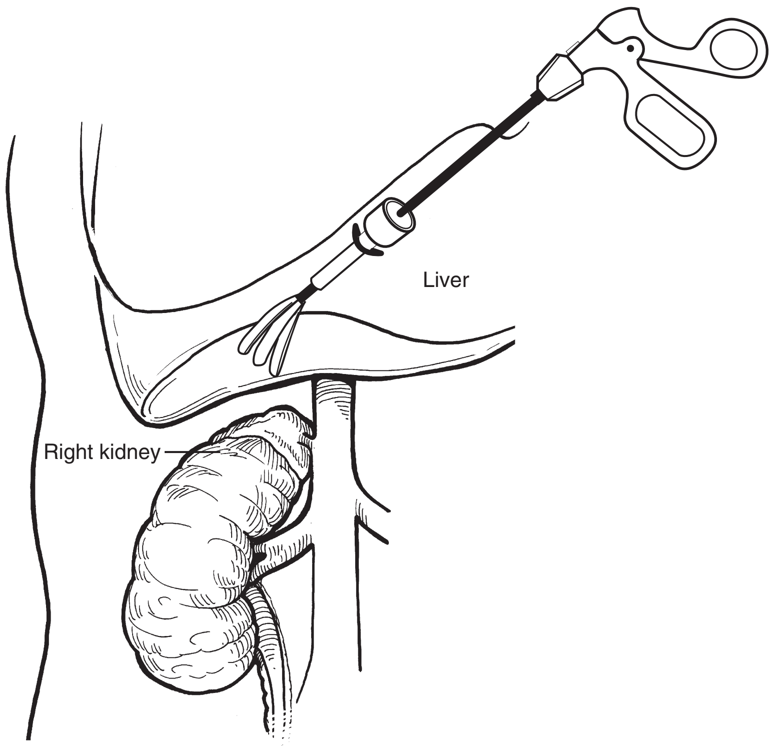


FIGURE 1–23. The fan retractor houses several arrays that can be passed through a standard trocar and then opened to provide a wide surface for retraction.

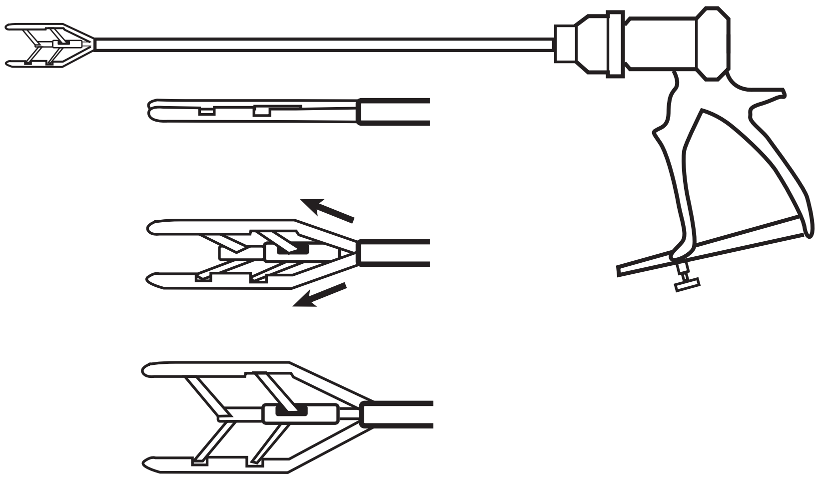


FIGURE 1–24. The PEER retractor (Jarit Surgical Instruments, Hawthorne, NY) can be placed through a standard trocar and opened to provide retraction of organs in a variety of situations, including the kidney, liver, spleen, and bowel.

RETRACTION

Abdominal retractors can be of great assistance in situations in which the organs must be displaced in order to see better during dissection. A standard grasper has the potential to perforate the organ it was intended to retract. Several retractors have proved to be valuable for surgery in the retroperitoneum. The fan retractor houses several arrays that can be passed through a standard trocar and then opened to provide a wide surface for retraction (Fig. 1–23).

The PEER retractor (Jarit Surgical Instruments, Hawthorne, NY) is available in 5-mm and 10-mm configurations and is opened after placement through the trocar to provide retraction in a variety of situations (Fig. 1–24).

The Diamond Flex Triangle retractor (Genzyme Surgical Products, Tucker, GA) is a 5-mm device that can be placed through a standard trocar. Once it is inside the abdomen, the handle can be tightened by pulling the tip into an angled, triangular shape that has a large surface area for retraction (Fig. 1–25).

Retraction can also be achieved without inserting an additional trocar site. Suture on a straight needle can be used when temporary retraction is needed on a structure such a kidney, ureter, or a portion of omentum. First, advance the needle through the abdominal wall under direct vision and pass it through or under the structure to be retracted. Then pass the straight needle back through the abdominal wall, and elevate and secure the two strands with a hemostat (Fig. 1–26).

Retraction of the liver during nephrectomy, adrenalectomy, or retroperitoneal lymph node dissection can be accomplished through an additional 5-mm or 3-mm port placed in the midline below the xiphoid process or below the costal margin in the midclavicular line. Preferably, pass a locking grasper under the liver; after grasping the peritoneal edge on the right

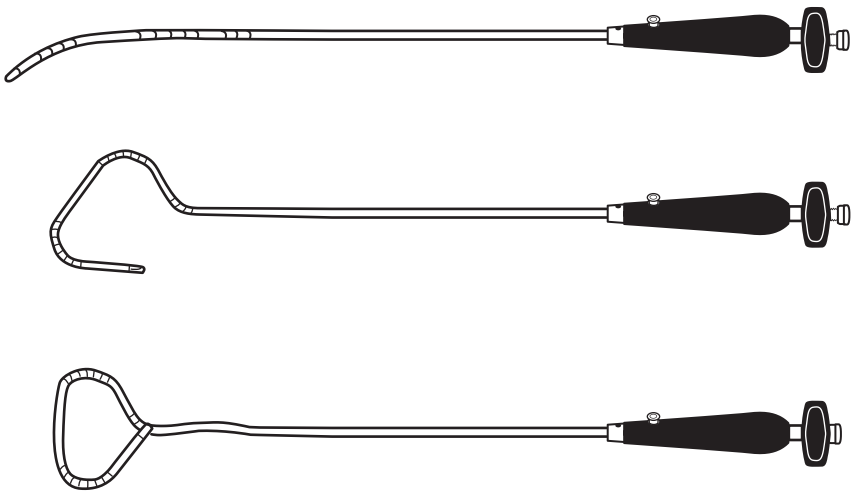


FIGURE 1–25. The Diamond Flex Triangle retractor (Genzyme Surgical Products, Tucker, GA) is a 5-mm device that can be place through a standard trocar. Once inside the abdomen, the handle can be tightened, pulling the tip into an angled, triangle shape with a large surface area for retraction.

lateral side wall, lock the grasper in place, retracting the liver from the field of dissection (Fig. 1–27).

During a left-sided dissection in which tissue is to be removed, a 10-mm or 15-mm EndoCatch (U.S. Surgical, Norwalk, CT) can be inserted for assistance. During nephrectomy, create a small incision in the skin approximately 2 fingerbreadths above the symphysis pubis and place a 15-mm device. Insert a 10-mm trocar to create a fascial opening, and then remove the trocar. Place the 15-mm EndoCatch, without a trocar, in the dilated skin site, through the fascia, and into the abdominal cavity; use the EndoCatch to provide retraction during the procedure. The size difference between the trocar and the EndoCatch allows a snug fit against the skin that maintains pneumoperitoneum during the procedure. In the case of nephrectomy, once the kidney is freed, the bag is deployed, and the kidney is entrapped and retrieved through a Pfannenstiel or low midline incision (Fig. 1–28). Alternatively, a 15-mm Thoracoport (U.S. Surgical, Norwalk, CT) can be used to create a seal with the 15-mm EndoCatch bag (U.S. Surgical, Norwalk, CT).

For bowel, ureter, and bladder retraction, the A-Trac (Applied Medical, Rancho Santa Margarita, CA) grasping system can be useful. Instead of using metal tips, the reusable locking instrument uses disposable inserts of mesh material on soft pads to grasp tissue and maintain traction, avoiding the crushing forces often seen with metal tip graspers.

HAND-ASSISTED LAPAROSCOPIC SURGERY

Since the first hand-assisted laparoscopic nephrectomy was performed in 1997 by Nakada and colleagues[9] during a simple nephrectomy to remove a nonfunctioning, obstructed kidney, the interest in hand-assist surgery has increased. The popularity of the hand-assist technique has launched an ongoing debate between the hand-assist surgeons and those who prefer pure laparoscopy, centered on the advantages and disadvantages of these two approaches. Proponents of the hand-assist technique assert the benefits of tactile sensation for dissection of blood vessels and obscured organs, spatial orientation, and the use of the hand for dissection, retraction, and suturing. When bilateral procedures are being performed, a midline hand-assist port can be of value in working on both kidneys and preventing repositioning of the patient. One of the greatest benefits of the hand-assist technique may be the ability to rapidly control bleeding, which prevents conversion to open surgery or at least permits conversion to open in a more controlled fashion than may be required during laparoscopic surgery.

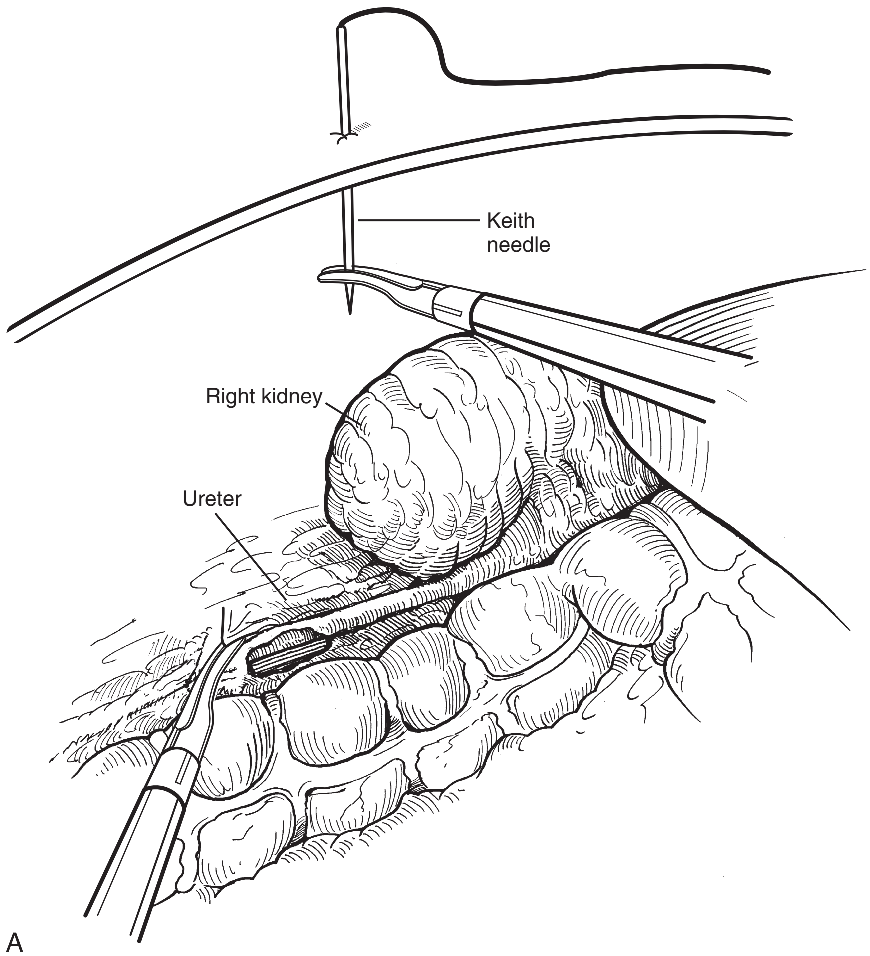
Surgeons who prefer pure laparoscopy argue that the hand incision results in a larger scar that is not necessary. In addition, they say that the hand inside the abdomen can obstruct the view and, in many patients, does not allow simultaneous retraction of the bowel medially and the kidney laterally during hilar dissection. Furthermore, they argue that hand-assist devices can cause painful compression of the surgeon's forearm and paresthesias, as well as shoulder and cervical neck pain.[10] They also point out the problem with leakage of hand ports causing loss of pneumoperitoneum and that it is not uncommon for some of the devices to tear or stretch during the course of the procedure, requiring replacement with a new device in order to finish the case.

Still, other surgeons find themselves between these two extremes, using the hand-assist technique for cases where the specimen is going to be extracted intact or when a difficult dissection is anticipated and using pure laparoscopy in the remaining cases. Some surgeons see the hand-assist device in a variety of ways:

1. A bridge to learn pure laparoscopy
2. A device to be used when surgeons are unable to progress in the case using laparoscopic techniques
3. An assist in learning new complex procedures[11]

There are three devices marketed for hand-assist surgery, each with different characteristics and nuances (Table 1–1). The hand-assist surgeon must be familiar with the particular characteristics of the chosen hand device to maximize its effectiveness and to prevent gas leak and loss of pneumoperitoneum during the procedure.[12,13]

The hand-assist devices allow tactile feedback and assistance with blunt dissection and retraction. Although the incision that these devices make is large enough to allow the surgeon or assistant to insert a hand, the incision size can be minimized and situated in such a way as to decrease the pain associated with flank incision or a larger open incision. The specimen can be extracted through the hand-assist incision site. An instrument port adapter is also available to cover the large entry site, maintain pneumoperitoneum, and accept laparoscopic working



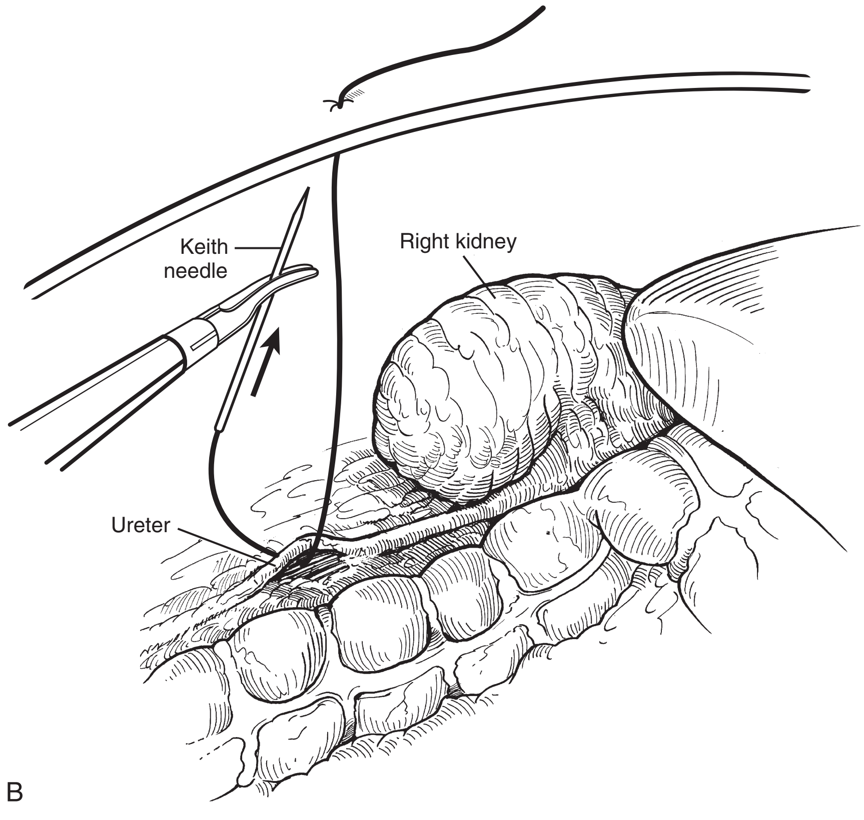


FIGURE 1–26. *A,* Retraction can be achieved without the insertion of an additional trocar site. When temporary retraction is needed, a straight needle with suture can be passed through the abdominal wall under direct vision. *B,* The needle is passed through or under the structure to be retracted.

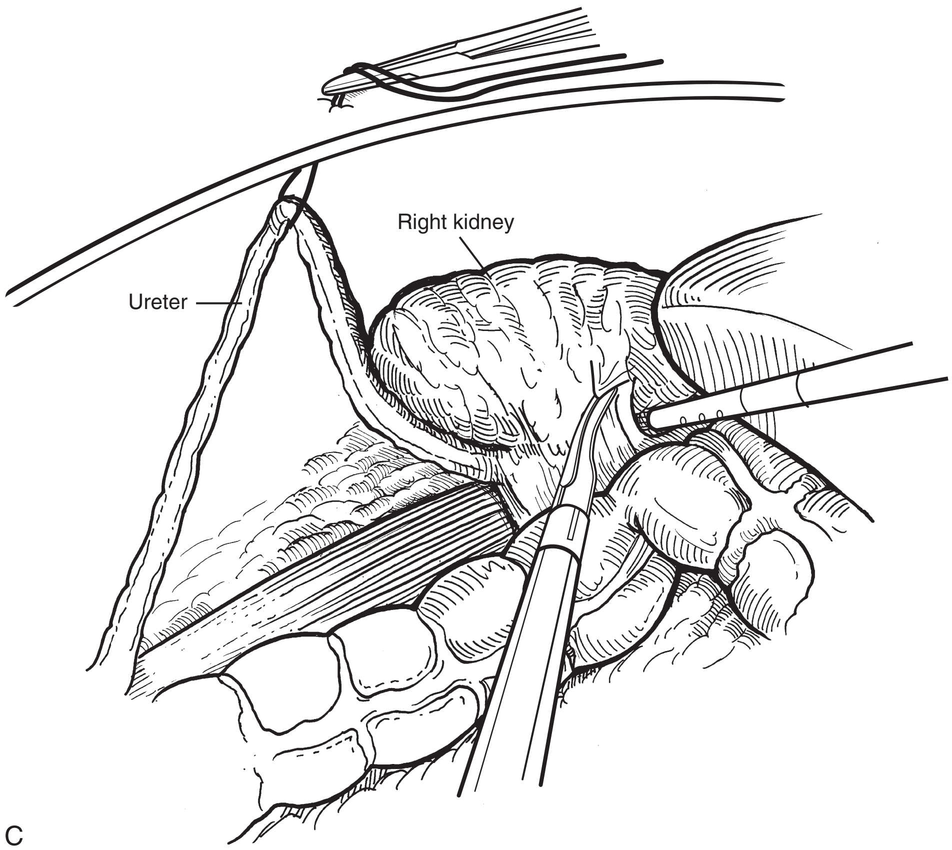


FIGURE 1–26, cont'd. *C,* The needle is passed back through the abdominal wall, and the two strands are secured with a hemostat.

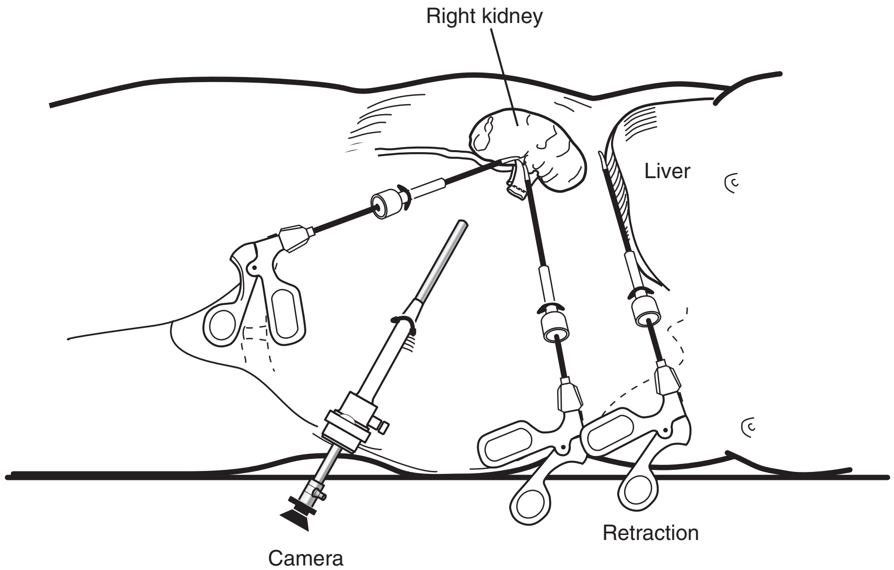


FIGURE 1–27. Retraction of the liver during nephrectomy, adrenalectomy, or retroperitoneal lymph node dissection can be accomplished through an additional 5-mm or 3-mm port placed in the midline below the xiphoid process or below the costal margin in the midclavicular line. Preferably, a locking grasper is available to pass under the liver and, after grasping the peritoneal edge on the right lateral side wall, can be locked in place, retracting the liver from the field of dissection.

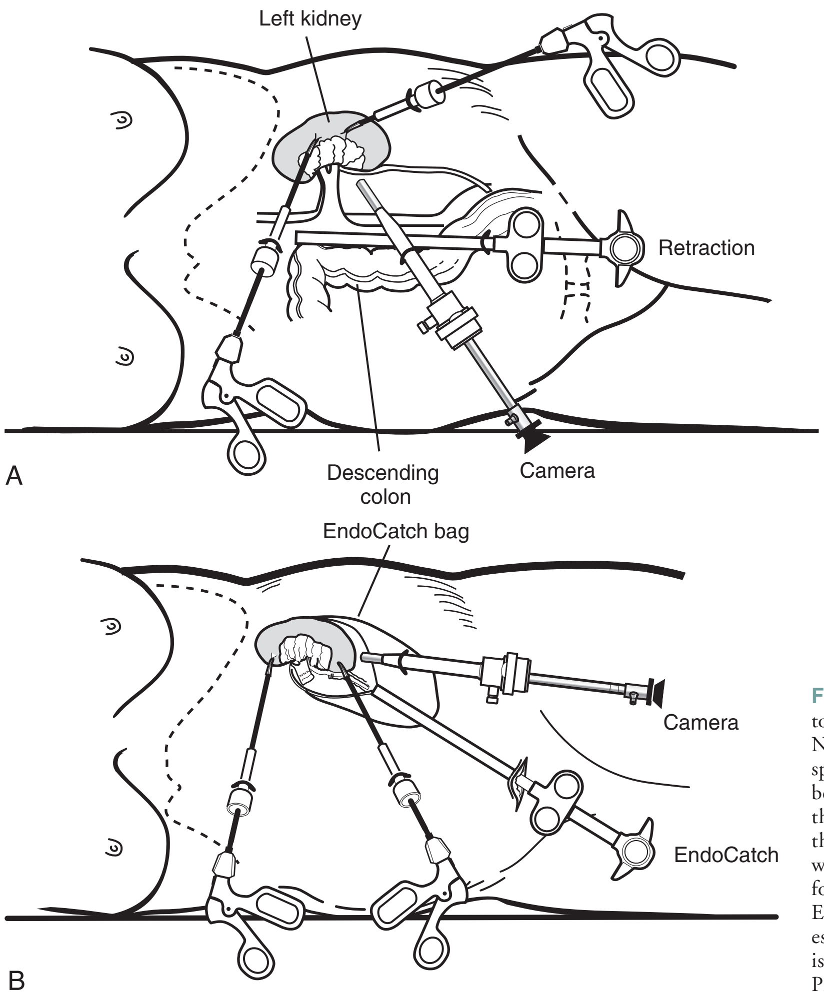


FIGURE 1–28. *A,* During a left-sided dissection where tissue is to be removed, a 10-mm or 15-mm EndoCatch II (U.S. Surgical, Norwalk, CT) can be inserted for assistance. For nephrectomy specimens, a 15-mm device is placed after a small incision has been created in the skin approximately two fingerbreadths above the symphysis pubis. A 10-mm trocar is then inserted to create the fascial tract and then removed. The 15-mm EndoCatch II, without a trocar, is then placed through the dilated site and used for retraction. The size difference between the trocar and the EndoCatch allows a snug fit against the skin that will prevent gas escape during the procedure. *B,* Once the kidney is freed, the bag is deployed, and the organ is entrapped and removed through a Pfannenstiel incision.

TABLE 1–1. CHARACTERISTICS OF COMMERCIALLY AVAILABLE DEVICES FOR HAND-ASSISTED LAPAROSCOPY

Characteristic	GelPort	Lap Disc	Omniport
Manufacturer	Applied Medical, Rancho Santa Margarita, CA	Ethicon Endo-Surgery, Cincinnati, OH	Advanced Surgical Concepts, Ireland, distributed in United States by Weck Closure, Raleigh, NC
Device diameter	13 cm	12 cm	12 cm
Number of different sizes	2	2	1
Number of components	3 Pieces: Flexible skirt, rigid base, gel cap	1 Piece	2 Pieces: Cuff with retention rings, insufflation device
Advantages	Gel cap maintains pneumoperitoneum with or with out instruments and allows instrument to be placed directly though cap device	Small and simple to work. An iris configuration allows opening to be large enough for hand or tightly placed around a trocar	Able to maintain pneumoperitoneum even when incision is too long
Disadvantages	Gas leak if incision is too long	Gas leak if incision is too long	Loss of pneumoperitoneum when hand is removed
Cost per device	$575	$490	$415

From Wolf JS: Tips and tricks for hand-assisted surgery. AUA Update series 24:2, 2005; Rane A, Dasgupta P: Prospective experience with a second-generation hand-assisted laparoscopic device and comparison with first-generation devices. J Endourol 17:895–897, 2003; and Rupa P, Stifelman MD: Hand-assisted laparoscopic devices: The second generation. J Endourol 18:649–653, 2004.

instruments. The hand-assist devices offer a bridge between laparoscopic and open surgery and may offer assistance for surgeons without advanced laparoscopic training who still want to offer laparoscopic advantages with a small midline incision. Hand-assisted dissection may also be helpful in patients whose pathologic condition makes laparoscopy more difficult, such as infectious processes or prior surgery.

Sections on hand-assisted procedures are included in this atlas with specific details on placement and dissection outlined for each procedure.

RETRIEVAL

Anyone who has struggled to place an organ or tissue in a bag will immediately appreciate advances in retrieval technology. The EndoCatch II is a self-opening bag that comes in several sizes including 10 mm and 15 mm. Once the instrument is placed through a trocar or directly through the skin, the inner core handle slides forward, advancing the bag. A metal band automatically opens the bag and can be used to scoop up the tissue to be removed. By pulling a separate string, the bag closes and tears away from the metal ring. The ring is pulled back into the handle and the device is removed, leaving the closed bag and string in the working space. The current bags are not strong enough to withstand automated tissue morcellation (Fig. 1–29).

The LapSac (Cook Urological, Spencer, IN) provides a sturdy nylon sac that allows the specimen to be morcellated with hand instruments. Placement of the organ into the LapSac is greatly facilitated by feeding a standard hydrophilic wire through the holes in the opening of the sac before inserting the

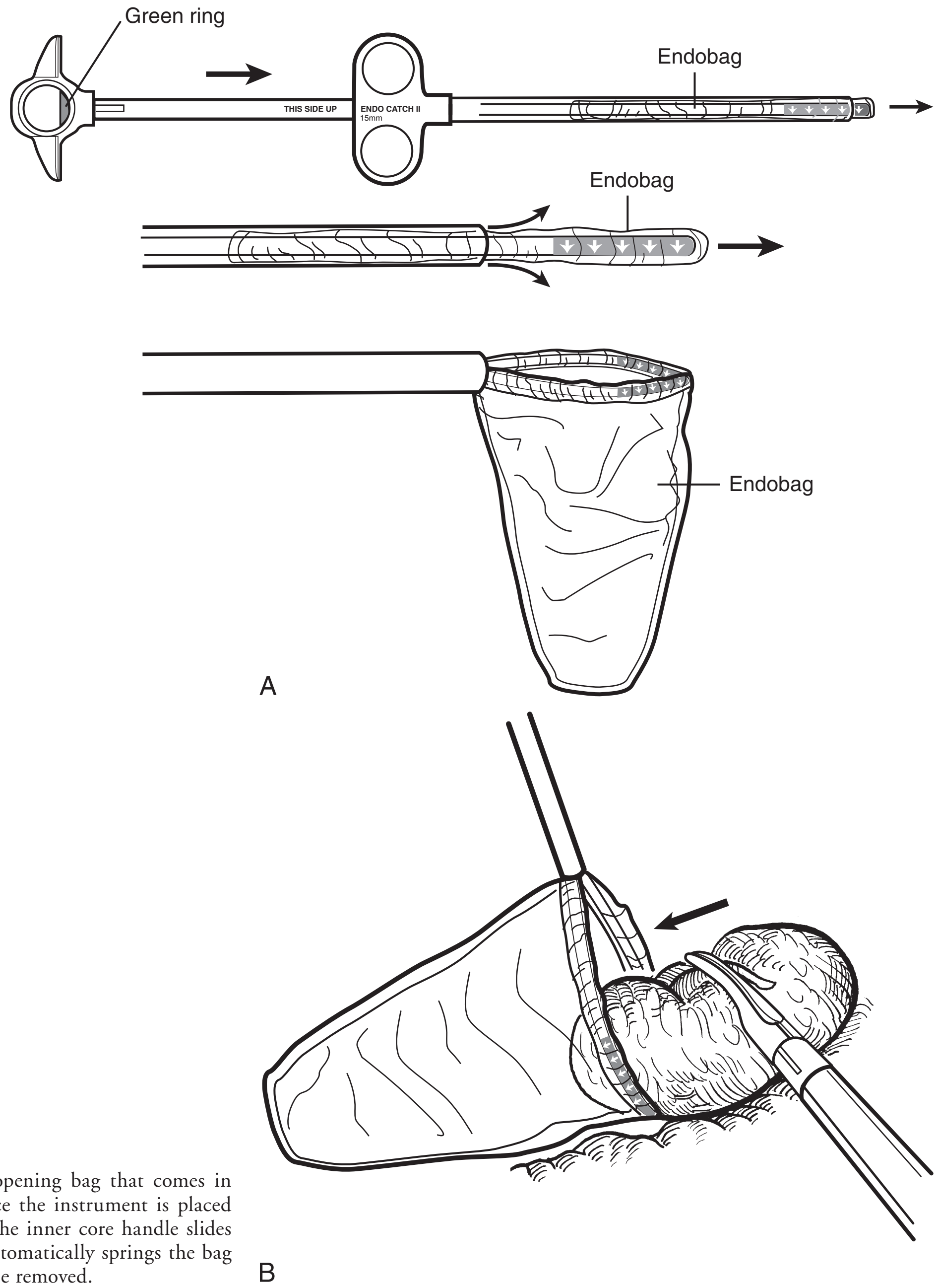


FIGURE 1–29. *A,* The EndoCatch is a self-opening bag that comes in several sizes including 10 mm and 15 mm. Once the instrument is placed through a trocar or directly through the skin, the inner core handle slides forward, advancing the bag. *B,* A metal band automatically springs the bag open and can be used to scoop up the tissue to be removed.

Continued

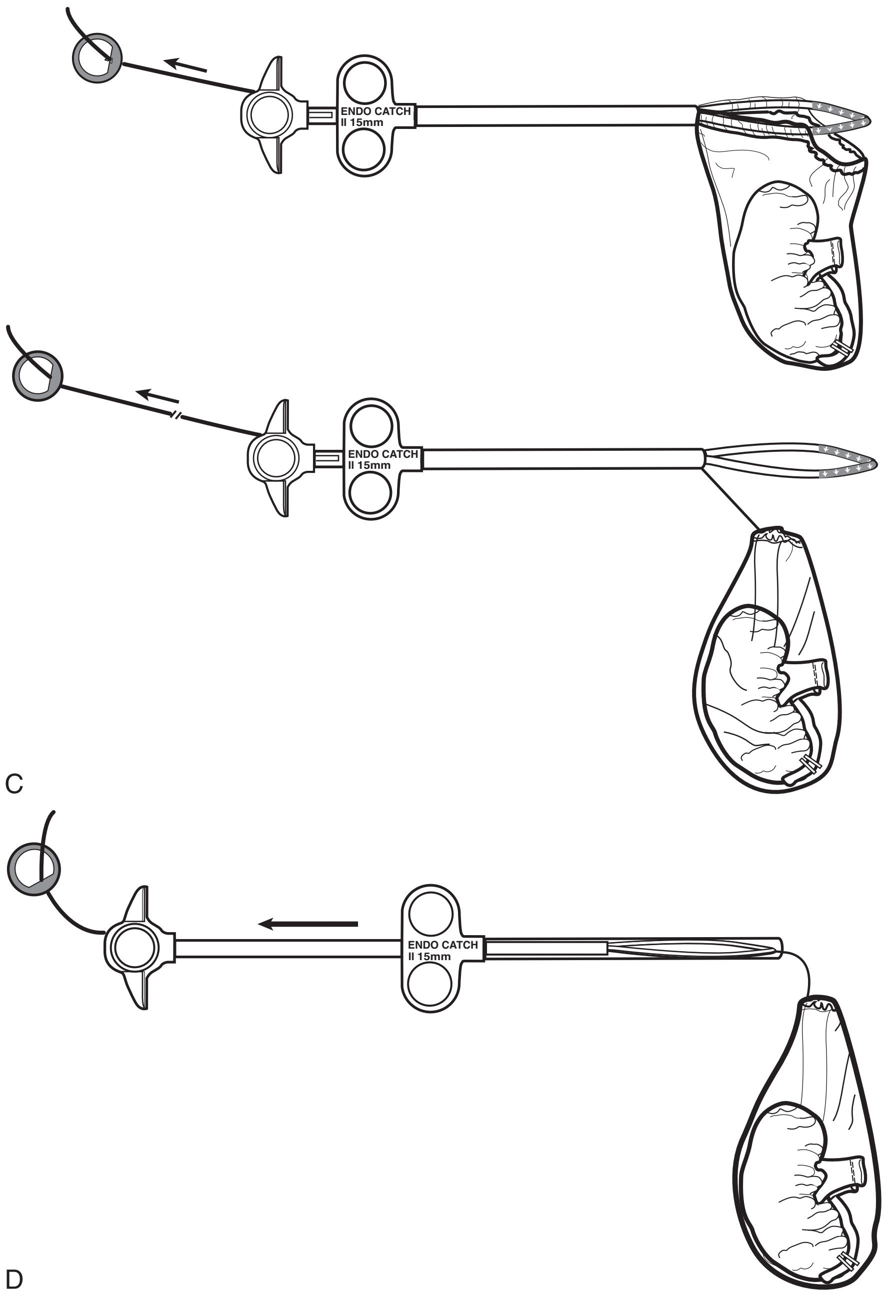


FIGURE 1–29, cont'd. *C,* A separate string is pulled, closing the bag and tearing it away from the metal ring. *D,* The metal ring is retracted back inside the sleeve, leaving the bag and string behind. The string is cut, leaving a long strand exiting the trocar site.

sac into the abdomen. Roll the sac and place it through the skin into the abdomen through a 12-mm trocar site with the trocar removed. The ends of the wire remain outside the abdomen. Then place the trocar back through the 12-mm skin incision. Using two instruments, unroll and open the sac, and use the wire to help hold the mouth open. After moving the specimen inside the sac, withdraw the wire and close the opening with the LapSac string. Then pull the sac through a 12-mm trocar site; I usually enlarge the site to approximately 2 cm. As the sac is pulled open, the entrapped tissue is seen at the opening. Using alternating bites with a ring forceps and Kocher clamp, carefully morcellate the tissue. Only grasp tissue crowning at the opening. Do not make deep passes into the LapSac because bowel outside of the sac can be inadvertently grasped and damaged.

For lymph node dissection and other procedures in which tissue is going to be extracted, a 10-mm EndoCatch can be used in a similar fashion without a trocar or passed through a 10-mm port inserted 2 fingerbreadths above the symphysis pubis. In addition, a 15-mm EndoCatch can be placed through a 15-mm Thoracoport (U.S. Surgical, Norwalk, CT) to maintain pneumoperitoneum during the procedure.

MECHANICAL ASSISTANCE

The Automated Endoscopic System for Optimal Positioning, or AESOP, robotic device (Computer Motion Inc., Goleta, CA) is a voice-activated assistant that holds and positions the camera for the surgeon during the procedure. The robot provides a

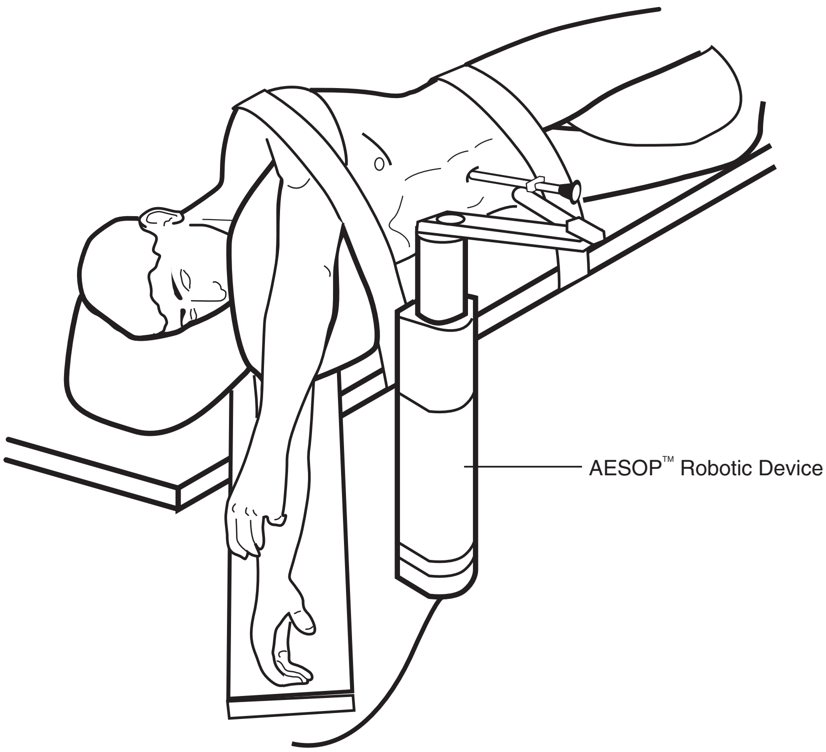


FIGURE 1–30. The AESOP Robotic Device (Computer Motion Inc., Goleta, CA) is a voice-activated assistant that holds and positions the camera for the surgeon during the procedure. The robot provides a motionless image, and the field of view is changed at the surgeon's command through use of a headset and the voice recognition system.

motionless image and the field of view is changed at the surgeon's command through a headset and the voice recognition system (Fig. 1–30).

The TISKA (Trocar and Instrument Positioning System) Endoarm (TISKA Endoarm; Karl Storz, Endoskope, Tuttlingen, Germany) is a system developed to assist with trocar and instrument positioning. This device maintains the position of the trocar sheath at a fixed point at the trocar puncture site while instruments or laparoscopes are changed or removed. Routine laparoscopic needs such as tissue retraction can easily be performed with this system. The TISKA Endoarm is not currently available in the United States.

INTRAOPERATIVE IMAGING

New advances in ultrasound technology allow laparoscopic imaging in many different situations. Intraoperative laparoscopic ultrasonography allows the surgeon to determine the presence of multifocal renal lesions or to evaluate complex cystic masses (Fig. 1–31). The presence of a renal vein tumor thrombus can be readily detected during nephrectomy, and appropriate measures must be taken to ensure adequate treatment. In some adrenalectomy cases and renal biopsy cases in the morbidly obese, the organ can be difficult to locate without intraoperative imaging.

New generations of laparoscopic US probes also allow needle biopsy of suspicious lesions through the probe (B-K Medical, Herlev, Denmark) (Fig. 1–32).

RETROPERITONEAL ACCESS

A transabdominal approach to retroperitoneal structures is preferred in most procedures. The transperitoneal approach is more familiar for the surgeon and allows immediate visualization of important anatomic landmarks.

Adipose tissue in the retroperitoneum and a small working space can be considerable visual barriers to rapid progress of the surgical procedure. In a transabdominal approach, the anatomic planes of dissection are similar to open surgery, making this approach easier for the beginning laparoscopic surgeon and resident-in-training to overcome the learning curve associated with this new skill.

Nevertheless, there are patients in whom retroperitoneal access is preferred. The patient with a history of multiple abdominal surgical procedures, in whom mesh for abdominal wall closure has been used, or with a history of peritonitis may benefit from this approach. The patient with a posterior exophytic cyst or mass may be better served through retroperitoneal access. Consequently, the laparoscopic surgeon needs to be familiar with both transperitoneal and retroperitoneal access.

There are several different methods to gain retroperitoneal access. Place the patient in the lateral decubitus position with the table flexed and the kidney rest extended; this increases the distance between the 12th rib and the anterior superior iliac crest. At the tip of the 12th rib, make a 1.5- to 2-cm incision and spread it down to the lumbodorsal fascia. Also incise the fascia and extend your index finger to create a working space toward the kidney or adrenal gland. Insert a handmade or commercial balloon system into the space and direct it toward the area of dissection. Instill normal saline in the balloon to create a 500- to 800-mL working space. After several minutes, deflate the balloon, insert a 10-mm Hasson trocar, and create the pneumoretroperitoneum (Fig. 1–33).

Instead of the balloon and Hasson trocar method, a trocar with a visual obturator can be used to access the retroperitoneum through a standard 1-cm incision. Once the trocar is in place and connected to the insufflator, insert the camera through the trocar and use it to bluntly push the peritoneum

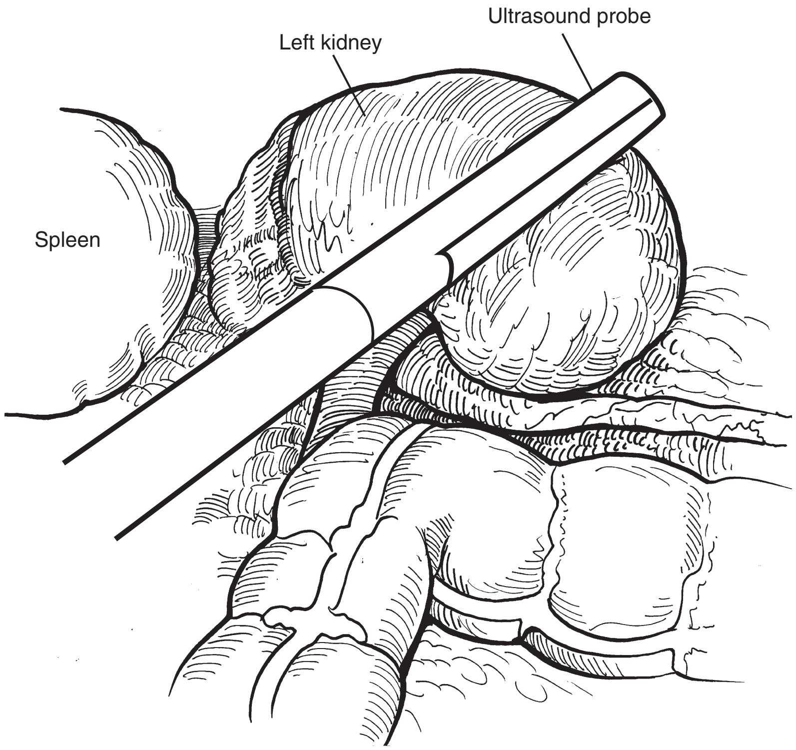


FIGURE 1–31. New advances in ultrasound technology allow laparoscopic imaging for many different indications. Intraoperative laparoscopic ultrasonography allows the surgeon to determine the presence of multifocal renal lesions or to evaluate a complex cystic mass or a tumor thrombus.

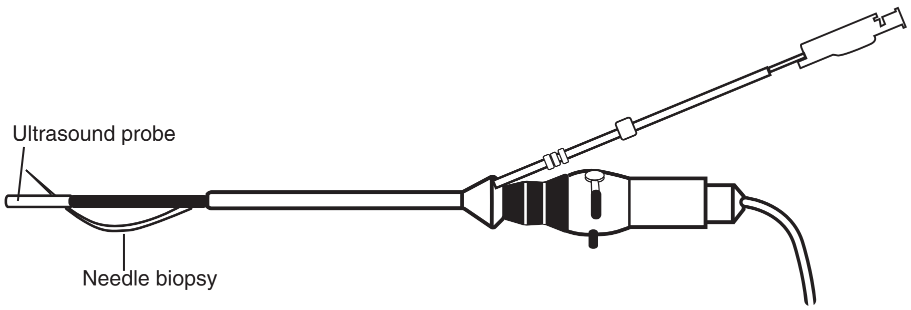


FIGURE 1–32. Some of the laparoscopic ultrasound probes allow needle biopsy of suspicious lesions for diagnosis (B-K Medical, Herlev, Denmark).

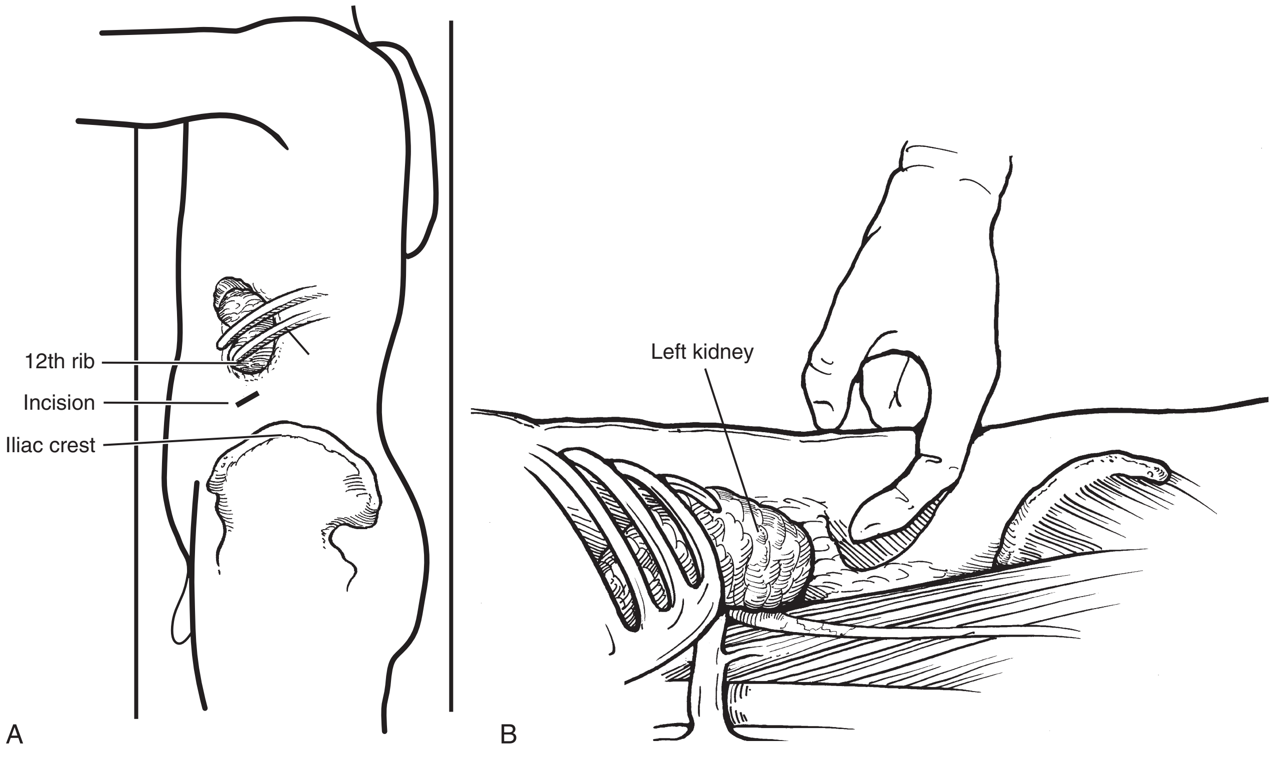


FIGURE 1–33. *A,* To gain retroperitoneal access, the patient is placed in the lateral decubitis position with the table flexed and the kidney rest extended. This increases the distance between the 12th rib and the anterior superior iliac crest. At the tip of the 12th rib, a 1.5- to 2-cm incision is created and spread down to the lumbodorsal fascia. *B,* The fascia is also incised, and the surgeon's index finger is extended to create a working space toward the kidney or adrenal gland.

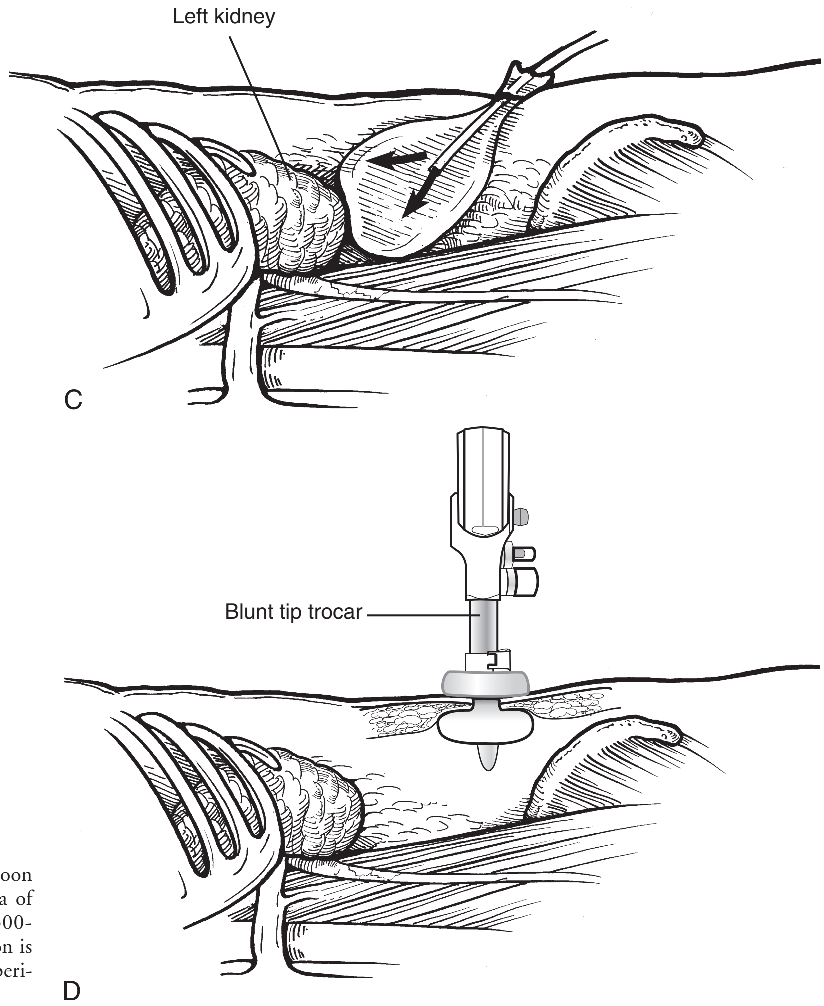


FIGURE 1–33, cont'd. *C,* A handmade or commercial balloon system is inserted into the space and directed toward the area of dissection. Normal saline is instilled in the balloon to create a 500- to 800-mL working space. *D,* After several minutes, the balloon is deflated, a 10-mm Hasson trocar is inserted, and pneumoretroperitoneum is created.

medially. The expanding working space is maintained by CO_2 as the scope is used to open tissue planes under direct vision.

Insert additional trocars according to the particular procedure being performed. Descriptions of the retroperitoneal approach (in addition to the transabdominal approach) are included in subsequent chapters on adrenalectomy, renal biopsy, and renal cyst decortication.

SUMMARY

Techniques in laparoscopic surgery have changed rapidly over the past 15 years, due in large part to advances in equipment. New technologies for trocar insertion, dissection, hemostasis, retraction, tissue retrieval, suturing, stapling, and intraoperative imaging have improved the ability to perform more complex laparoscopic surgeries.

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CHAPTER 2

Laparoscopic Stapling and Reconstruction

Gyan Pareek
Stephen Y. Nakada

Since the introduction of the laparoscopic nephrectomy in 1991 by Clayman and colleagues,[1] urologists have accepted that extirpative laparoscopic renal surgery is the first-line approach in most cases. Recent advancements in equipment technology have increased the laparoscopic applications in urology to more reconstructive type of procedures, including ureterolysis, ureteroureterostomy, nephropexy, pyeloplasty, and radical prostatectomy.

As with any type of surgery, methods and devices for hemostasis and tissue approximation are vital in laparoscopic surgery. Laparoscopic stapling and clipping devices are available for ligating vessels, approximating peritoneum, placing mesh, closing a viscus, and obliterating a lumen. Like their open-surgery counterparts, these devices were developed as faster, more efficient alternatives to hand suturing. Because intracorporeal suturing and knot tying are essential to nearly all these procedures, mastering these skills is essential for the retroperitoneal surgeon. This chapter provides a detailed description of the various clips, staples, and suturing techniques required to perform these laparoscopic urologic procedures.

CLIPS

Equipment

Occlusive clips are ideal for smaller arteries and veins and are now standard equipment in all laparoscopic procedures. As in open surgery, clips provide a rapid alternative for hemostasis. Today, most endoscopic clips are titanium, and they vary in size from 5 to 12 mm. There are absorbable clips, and some research shows no difference in adhesion formation between metallic and absorbable clips.[2]

The actual clips have characteristic ridges and valleys stamped onto the surface that is in contact with the tissue. Ideally, the variegated pattern prevents the clip from being dislodged by increased vascular pressure or by subsequent nearby tissue dissection. An occlusive clip starts out in a V shape; as it is squeezed by the applier, the tips close first, from distal to proximal (Fig. 2–1). This manner of closing ensures that the entire structure to be ligated is contained within the clip. Nonabsorbable polymer ligating clips (Weck Closure Systems, Research Triangle Park, NC) are also available (Fig. 2–2). These clips perform the same function as sutures by penetrating and locking through multiple layers of tissue. The engaging clip latching mechanism allows the surgeon to feel and hear the clip close. Use of the polymer ligating clip has been reported to be safe for renal artery ligation during nephrectomy.[3]

Occlusive clip appliers can be broadly classified into various categories: multiple load or single load and disposable or multiple use. Originally, the standard clip applier was single load and multiple use. The main advantage of the reusable units is their cost savings after initial investment. The disadvantages of these older models follow:

1. Extra time to exit and reenter the abdomen to load the clips
2. Tendency for loaded clips to fall from the jaws as they pass through the trocar
3. Lack of rotating shafts
4. Initial cost, which is four to six times that of disposable units

AutoSuture (U.S. Surgical, Norwalk, CT) offers a multiple-load, multiple-use model. However, this device is not as widely used because the multiple-load tools do not withstand the rigors of stocking, resterilization, and multiple uses.

The majority of laparoscopic clip appliers used today are single use and multiple load, carrying between 15 and 30 clips per unit (Table 2–1). The ability to fire multiple clips without exiting the abdomen to reload can save significant time and minimize blood loss in the case of clipping a bleeding vessel.

The diameter of the shaft generally depends on the size of the clips. Shafts of 5 mm are available for medium clip appliers. The EndoClip 5-mm shaft, single-use clip applier (Ethicon Endo-Surgery, Cincinnati, OH) can deliver a slightly larger clip than other 5-mm clippers; its hinged jaws are normally retracted within the shaft, but when the handles are squeezed, the jaws advance and expand and a clip is automatically loaded. Otherwise, for medium-large and large clips, the shaft sizes are 10 mm and 12 mm, respectively.

In addition to their multiple-load capabilities, the disposable units have several other notable features. First, 360-degree rotating shafts are present on nearly all appliers. This important feature allows the handle of the instrument to lie comfortably in the hand while the applier's tips are placed around the target tissue at an ideal angle. No articulating clip appliers are currently available. Second, automatically loading clips, which are available in many models, eliminate another step in clip application; immediately after a clip is placed, another one is advanced into firing position. Also, the automatically loading clips do not fall from the applier's jaws while being passed through the trocar as easily as from the single-load, multiple-use appliers. One potential disadvantage of automatic clip loading is that the tips of the clip applier cannot be used as a dissecting tool without possibly dislodging the unfired clip into the field. However, some clippers require the user to pull a trigger on the handle to load the clip. On newer models, the clip is loaded only when the surgeon begins to close the handles, without the requirement of pulling a separate lever. Third, most

new models have a visual indicator to alert the user that only a few clips are left. A safety feature that is not available in all appliers is an automatic lock that prevents the jaws from closing when the device is out of clips.

Instrument Use

The vessel or other structure to be clipped is dissected until the entire structure can be contained within the clip without a significant amount of interceding tissue. This step prevents the clip from slipping off and ensures that it has maximal contact with and pressure on the vessel. Also, the dissected window must be large enough to allow placement of several clips, with enough room left over to divide the structure with endoscopic scissors. On a small- to medium-sized vessel, one or two clips on either side usually suffice. For larger structures (e.g., renal artery), three clips are applied proximally and two clips distally before the vessel is divided.

Before placing the jaws around the tissue, ensure that there is a clip in place because closing the jaws without a clip could sever the structure. Once the clip applier's jaws completely surround the structure and the tips are easily seen, gently squeeze the handle until the tips of the clip just meet (Fig. 2–3). Then slide the clip up or down the structure for ideal positioning and finish by firmly squeezing the handle.

Withdraw the clip applier at the same angle used for the approach to avoid accidentally pulling off the clip. The Ligaclip Allport 5-mm clip applier (Ethicon Endo-Surgery) has a hinged jaw and uses a unique clip (see Fig. 2–2). After applying the clip, a small lip on the tip of the serrated jaw (see Fig. 2–3)

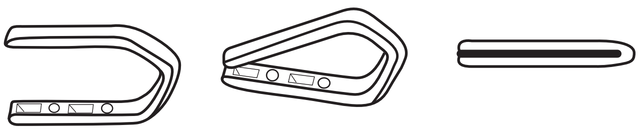


FIGURE 2–1. Standard laparoscopic clip closes from distal to proximal, with tips touching first.

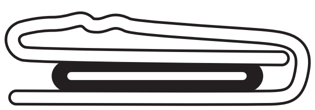


FIGURE 2–2. Hem-o-lok (Weck Closure Systems, Research Triangle Park, NC) nonabsorbable polymer ligating clip.

requires the user to back off the clip before withdrawing the applier to avoid dislodging the clip. If the clip is misplaced, use a Maryland-style forceps to withdraw it through the port.

Place additional clips as necessary, then use laparoscopic scissors to divide the tissue. Avoid using electrocautery to divide the vessels in order to avoid tissue necrosis and late failing of the clips. On larger vessels, we prefer to place clips in an alternating fashion so that the tips of the clips are facing opposite directions. A right-angle clip applier is ideal for this purpose and for other hard-to-reach structures. With current technology, the height of the clip and jaws limit the right-angle clip applier to 10-mm ports.

BITING CLIPS AND SINGLE STAPLES

Equipment

Use biting or tacking clips and staples to rapidly approximate tissue and to fix mesh without needing to place many individual sutures. Laparoscopic biting staplers originally were developed to repair laparoscopic hernia with mesh, but these devices are also useful in refashioning the peritoneum in laparoscopic ureterolysis and fixing mesenteric defects in bowel resections. Much like the staplers used for skin wound closure, laparoscopic staplers fire titanium staples with sharp ends that enter the tissue and then undergo deformation into either a B shape or a rectangle (Fig. 2–4).

Most contemporary devices are single-use and multiple-load, with 15 to 30 staples per unit. Disposable staplers typically cost more than those for the single-load reusable models, but the multiple-load feature makes their use much more efficient than withdrawing the instrument for each new biting clip to be placed. If the surgeon needs more than the 15 to 30 staples originally loaded, many new staplers allow for reloads, rather than requiring the use of another unit. A 360-degree rotating shaft is essential for accurate placement of the staple while allowing the squeeze-handle to rest comfortably in the hand. Some devices also come with a 60- to 65-degree distal articulating head, which permits the stapling of hard-to-reach areas like the anterior abdominal wall and deep pelvis.

Firing a Biting Clip: Technique

To reapproximate the peritoneum, as during intraperitonealization in a laparoscopic ureterolysis, introduce the biting stapler through its 10/12-mm port, which is ideally at a 90-degree angle with the target surface.

TABLE 2–1. DISPOSABLE, MULTIPLE-LOAD SINGLE-USE LAPAROSCOPIC CLIP APPLIERS

	Ligaclip Allport	Ligaclip Right-Angle	Ligaclip MCA	EndoClip	EndoClip II	EndoClip Multapplier
Manufacturer	Ethicon Endo-Surgery	Ethicon Endo-Surgery	Ethicon Endo-Surgery	AutoSuture	AutoSuture	AutoSuture
Port size (mm)	5	10	12	5	10	10
No. of clips	20–30	20	20	20	20	8
Sizes of clip	Medium, medium-large, or large	Medium-large	Large	Medium-large	Medium-large, large	Medium-large, large
Clip loading	Automatic	Automatic	Automatic	Separate lever	Automatic	Automatic

Ethicon Endo-Surgery, Inc., Cincinnati, OH; AutoSuture, U.S. Surgical, Norwalk, CT.

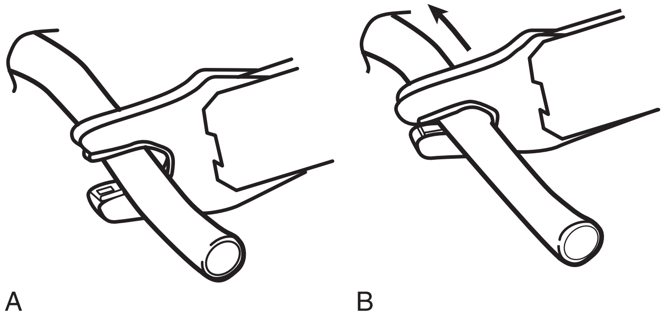


FIGURE 2–3. Clip ligation of a vessel. The jaws are closed until the tips meet *(A)* and then closed and moved proximally and closed tightly to occlude vessel *(B)*.

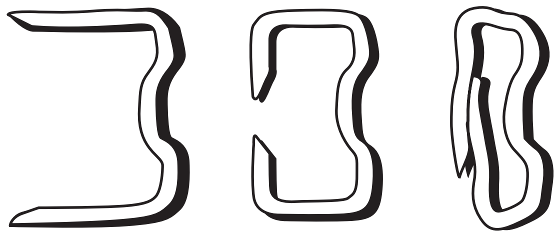


FIGURE 2–4. Biting clip deforms to a final rectangular shape.

Before grasping and reapproximating the peritoneum, position the stapling head at approximately the anticipated angle of stapling. This maneuver avoids prolonged traction on and tearing of the tissue. With an articulating stapler, angle the head so that the distal articulating shaft is perpendicular to the surface; then rotate the shaft until the firing head is at a right angle to the defect.

Next, secure each free peritoneal edge with separate graspers and pull the edges together until they meet. Poise the stapler head over the two edges and squeeze the handle gently only until five or six "clicks" are felt and the two staple tips protruding from the end of the stapler head can be seen.

Advance the points of the staple into the tissue and squeeze the handle the rest of the way. Once a few clips have been placed, only a single grasper may be needed to reapproximate the peritoneal edges.

LINEAR STAPLERS

Equipment

Laparoscopic linear staplers are vital tools for rapid, safe intracorporeal tissue division and reapproximation of visceral structures. With the squeeze of a handle, such a device deploys multiple, closely spaced, parallel rows of titanium staples.

Staples come in three different "loads"—thin/vascular, medium, and large/thick—and are color-coded for easy recognition.

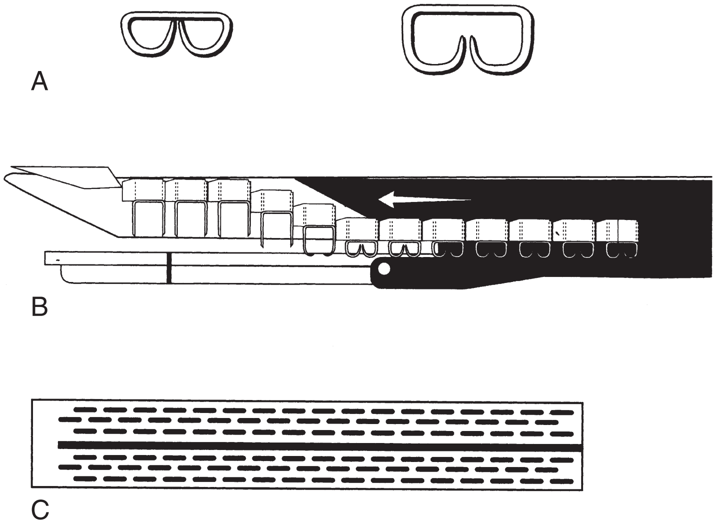


FIGURE 2–5. Linear staplers. *A,* Vascular staple forms a tighter B shape than a regular or thick staple. *B,* Linear stapler jaws, side view: Upon firing of the stapler, staples are forced downwards against the anvil and conform to their characteristic shape. The staples continue past the cut line to ensure hemostasis. *C,* Standard load: Three parallel rows of staples on either side of the cut line.

1. *Thin/vascular* staples penetrate tissue to a depth of 2 to 2.5 mm, deform to an exaggerated B shape, and form a reliably hemostatic staple line; they are ideal for rapidly ligating vascular pedicles and dividing thin, vascular mesentery.
2. *Medium* staples are 3.0 to 3.9 mm thick in their closed form and are useful in securing thicker tissues such as bowel, bladder, and ureter.
3. *Large* staples are 4.0 to 4.8 mm thick in their closed form and are also useful in securing thicker tissues. Larger staples do not fold to the same tight shape as small staples, and are not used for primarily hemostatic ligation.

Staples find their final shape as follows. With the target tissue secured between the two jaws of the stapler, staples are forced out of the load, through the tissue, and against an opposing anvil, where they reflect back upon themselves (Fig. 2–5).

Several years ago, a stapler could be reloaded only four times before its inner workings became unreliable (or the knife too dull) and it had to be discarded. Staplers today allow the same instrument to fire between 8 and 25 separate loads before disposal (Table 2–2).

Linear staplers can be broadly classified into cutting and noncutting staplers. *Cutting* versions deploy loads with six intercalated parallel rows of staples. As the staples are fired, a knife follows closely behind and incises the tissue down the middle of the load, leaving three rows of staples on each side. The staple line extends past the range of the cutting knife by one or two staples to avoid incising nonsecured tissue (see Fig. 2–5). Once the staples are fired, a safety feature on all such devices prevents accidental redeployment of the cutting knife until a new load with staples is in place. *Noncutting* staplers, which simply fire three or four parallel rows of staples, are useful for closing enterotomies and repairing bladder injuries.

Laparoscopic linear cutting staplers are further distinguished by the length of their staple line (30/35, 45, and 60 mm) and whether or not their firing heads are articulated. An articulating head gives a greater range of motion from a fixed trocar

TABLE 2–2. LINEAR STAPLERS

	Endopath ETS	Endopath ETS-Flex Articulating	Endopath EZ45: Cutter	Endopath EZ45: No-Knife	Multifire Endo GIA 30	Multifire Endo TA 30	Endo GIA Universal
Manufacturer	Ethicon Endo-Surgery	Ethicon Endo-Surgery	Ethicon Endo-Surgery	Ethicon Endo-Surgery	U.S. Surgical	U.S. Surgical	
Port size (mm)	12	12	12	12	12	12	12
Staple size(s)	Vascular/thin, regular	Vascular/thin, regular	Regular, thick	Regular, thick	2.0, 2.5, and 3.5 mm	2.5 and 3.5 mm	2.0, 2.5, 3.5, and 4.8 mm
Staple length(s) (mm)	35	35	45	45	30	30	30, 45, and 60
Rotating shaft	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Articulating	No	Yes	No	No	No	No	Yes

Ethicon Endo-Surgery, Inc., Cincinnati, OH; U.S. Surgical, Norwalk, CT.

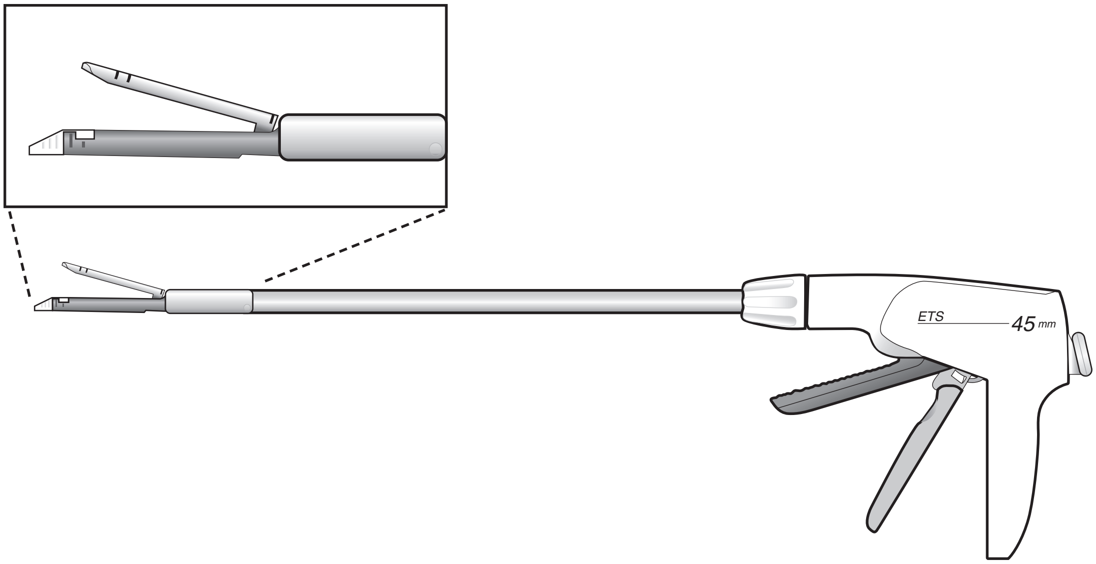


FIGURE 2–6. Endoscopic stapler (Ethicon, Cincinnati, OH). The ETS-Flex stapler rotates and the head articulates.

but adds to the stapler's price. All devices offer a rotating shaft, which is essential for proper visualization of the tips during firing.

On most models, a replacement load consists of a fresh six rows of staples but uses the same knife and anvil inherent to the actual stapling device. The ETS-Flex stapler (Ethicon, Cincinnati, OH) is illustrated in Figure 2–6. The stapler is unique in that the head of the stapler articulates, allowing application at various angles.

The minimum size limitation imposed by the width of the staple load requires use of a 10-mm or larger port for all currently available staplers.

Firing a Linear Stapler: Technique

Choose the appropriate stapler or staple load according to the following criteria:

1. Accessibility of the tissue to be stapled
2. Tissue thickness
3. Whether the tissue is vascular or nonvascular
4. Whether a cutting or noncutting staple is needed

Introduce the stapler with its jaws closed through a 12- or 15-mm port under direct vision and then observe through the laparoscope while moving the stapler to the prepared site. Ideally, watch the stapler head from the side; do not look down the shaft of the instrument. Then rotate the shaft and use any articulating features to position the head of the stapler. The jaw holding the staple load is on the back of the instrument, ready to be passed through the tissue window once the jaws are opened.

Next, retract the target tissue with graspers to open the tissue window, open the jaws of the stapler, and pass the jaw holding the staple load through the window. The end of most staplers can be used to perform some additional blunt dissection as necessary. Advance the jaws of the stapler until the tips are well beyond the far edge of the tissue and close the jaws to their locked position. If too much tissue is included, the jaws may not be parallel after being closed. This situation poses a risk that the distal staples will not come in contact with the anvil and thus will not conform to the appropriate B shape. With the stapler's jaws locked, observe that the so-called cut lines printed on either side of the stapler's head are distal to the tissue to be incised. There are safety measures

built into each model that must be deployed before firing the staples.

Next, fire the staples, reopen the jaws before withdrawing the instrument from the staple site, and immediately ensure that the staple line is intact and occlusive. Finally, close the handles under direct vision with the laparoscope and remove the instrument for another load if necessary. The proper use of the stapler is essential because malfunction can lead to devastating consequences. Chan and associates[4] reported a 1.7% stapler malfunction rate (10 of 565 cases) during laparoscopic nephrectomies performed over a 10-year period. Interestingly, 7 of the 10 malfunctions may have been attributed to misuse of the stapling device.

LOOP LIGATION

Equipment and Use

Loop ligatures are most valuable in securing an already transected pedicle. Pass a length of suture with a preformed sliding, locking knot intracorporeally, whether self-tied or commercially prepared. Then retract the structure to be ligated through the loop with a grasper, and cinch the loop down with a knot pusher (Fig. 2–7).

Any slipknot can be used, but it must be reliable and must not backslide once cinched tight. One popular knot is the Roeder knot (Fig. 2–8), which was first used for loop ligation in tonsillectomy. A reliable knot, it can be made even stronger by throwing an extra half-hitch after tying the main body of the knot. Use a sliding knot pusher to advance the knot. Once the loop is in place around the tissue, pull back the free proximal end of the suture through the pusher to cinch the knot. To ensure the tightest knot possible, keep the tip of the pusher in tight apposition to the tissue while closing the loop. Depending on the size of the knot pusher and trocar, a reducing sleeve is often required to prevent leaking from the trocar site when the knot pusher is advanced into the body.

Two popular prefabricated loop ligature systems are Surgitie (U.S. Surgical, Norwalk, CT) and EndoLoop (Ethicon Endo-Surgery, Somerville, NJ). The Surgitie kit contains a reducing sleeve for a 5-mm port, a knot pusher, and a preloaded suture with loop. Pass the knot pusher and attached loop through the reducing shaft and then through the trocar, and advance them to the surgical site. Next, an assistant passes a grasper through the loop, locks its jaws on the tissue to be ligated, and retracts

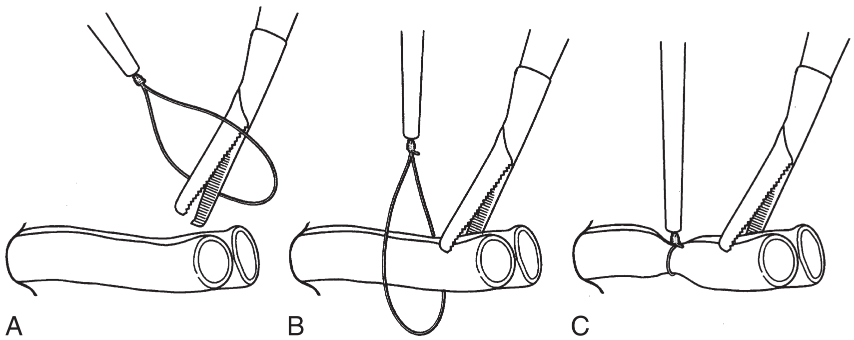


FIGURE 2–7. Loop ligation is performed with (*A*) a preformed loop that is passed into the body. *B,* The tissue to be ligated is grasped and pulled through the loop. *C,* The knot is cinched tight with a knot pusher three or four times.

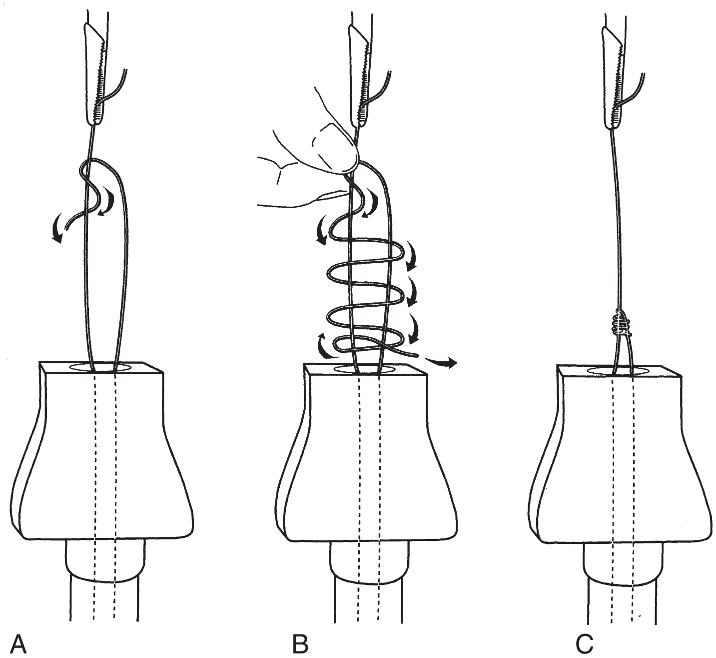


FIGURE 2–8. The Roeder knot is a sliding, locking knot used to create a preformed loop and for extracorporeal knot tying. *A,* Simple half-stitch is thrown. *B,* Half-stitch is pinched between the thumb and the forefinger, and the free end of the suture is passed around the two strands three to seven times. The free end of the suture is passed through the two strands and the knot is tightened. *C,* Finished knot with the free end trimmed.

the tissue back through the loop. (Alternatively, if the tissue is not retractile, the loop may be advanced distally along the length of the grasper's shaft.) With the knot ready to be cinched, snap off the proximal 2 cm of the plastic knot pusher, breaking the shaft into two pieces. With one hand, pull back the short proximal piece with attached suture while using the other hand to advance the knot pusher over the suture. Finally, cinch the knot two or three times and cut the suture.

The advantage of this prefabricated loop ligature system is that it requires no setup and is ready to use right out of the package. Available suture materials are both 0 and 2-0 plain gut, chromic gut, polyester, and synthetic absorbable varieties. The plastic knot pusher is available in only one length and may be too short to reach the target site if the wrong port is chosen. One minor inconvenience of this and other similar systems is that both hands are needed to cinch the knot, thus requiring an assistant to grasp the tissue and hold it still.

The EndoLoop loop ligature device is part of a larger endoscopic suturing system called EndoSuture (Ethicon Endo-Surgery). Unlike the disposable knot pusher and reducing sheath in other systems, the reusable metal EndoHandle and associated metal shaft can be reloaded with a variety of different sutures: EndoLoop ligature, needle with preformed loop, or simple suture-needle combination (Fig. 2–9*A* and *B*). With the EndoLoop suture loaded, pass the EndoHandle shaft through a 5-mm trocar, and introduce the loop to the surgical site. Once the loop is around the tissue and ready to be tightened, pull the proximal end of the suture backward. At the same time, the EndoHandle shaft with its disposable tapered plastic tip pushes the knot into the tissue and closes the loop. The proximal end of the suture is attached to a plastic button that is designed to be slid along the EndoSuture handle using only the thumb. This one-handed loop-tightening feature leaves one hand free for other tasks, such as grasping and retracting. Other advantages of this system are the reusable handle, generous shaft length, and 5-mm trocar compatibility without the need for a reducing sheath. This system has two minor drawbacks: (1) the extra time it takes to load the suture onto the EndoHandle and (2) the tendency to cause CO_2 leakage from the rubber trocar seal.

Although commercially preformed loops cost more than a length of suture, they save precious operating room minutes and are the preferred means of loop ligation.

LAPAROSCOPIC SUTURING

The introduction of occlusive clips, linear staples, tacking clips, and preformed loops has greatly aided laparoscopic surgery. Despite this technology, the laparoscopic surgeon must be able to efficiently perform simple-interrupted and running suture closures. The special limitations in laparoscopic surgery make this task among the most difficult to master, including fixed port sites, limited field of view (especially with new 5-mm–port scopes), two-dimensional monitor image under the control of another operator, and difficulty maintaining a bloodless field.

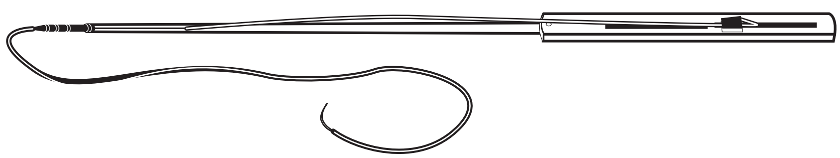
The ideal laparoscopic suturing device allows the surgeon to place a stitch at any angle despite trocar position and then automatically throw a perfect, reliable knot. This product does not exist, but several available devices make the task easier. Each device is discussed in the context of performing a simple-interrupted stitch and running suture line.

Preparation for Suturing

A minimum of three ports (preferably four) are needed for laparoscopic suturing: two ports for the needle driver and assisting grasper, one for the laparoscope and camera, and one for retracting tissue or suctioning. Choose the needle driver port so that the shaft of the driver is nearly parallel with the length of the wound. Locate the assisting grasper port at least 10 cm from the needle driver port to prevent the so-called crossing-swords phenomenon. Finally, place the laparoscope port so that the left-handed and right-handed instruments move the same way on the video image as they do in real life.

Ideally, these requirements involve placing the camera port between the two working ports. However, this placement often makes it difficult for the assistant (who is often on the other side of the table) to control the camera and perform retraction at the same time. The alternative is to place the camera port lateral to the two working ports. Avoid placing the camera port so that it is looking back on the working instruments; this arrangement makes suturing very difficult because the left- and right-hand movements are reversed on the monitor.

Take advantage of the laparoscope's magnification ability by using close-up views when actually placing the sutures. Moving the camera closer to the surgical site reduces the depth of field, thus minimizing the constraints of a two-dimensional image.



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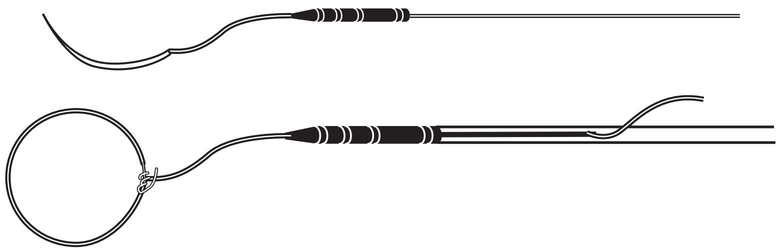

B

FIGURE 2–9. EndoSuture system (Ethicon, Cincinnati, OH). *A,* Metal handle and shaft with needle and suture load. A plastic knob at the proximal end of the suture fits into the groove on the handle. This knob can be slid up the handle with the surgeon's thumb to take up slack while the shaft is advanced during knot advancement. *B,* Close-up of the shaft tip with the preformed loop created by sliding the plastic knob on the handle.

Wide-angle shots are good for intracorporeal suture tying and for picking up the needle.

Sutures and Needles

Choice of suture in laparoscopy depends on the thickness and texture of tissue and whether sutures are to be permanent or absorbable. These considerations are similar to those in open procedures. For freehand suturing techniques, nearly all types of suture and needles are available. Choices are more limited for the use of the newer suturing devices.

As with open surgery, make more knots with monofilament sutures to avoid slipping. Handle suture carefully with atraumatic graspers to avoid fraying braided sutures and kinking monofilaments. Take extra care with the suture because the suture is handled by more instruments during laparoscopic surgery.

The length of suture for a particular knot or type of suture is another important consideration. For extracorporeal knotting, the suture is between 60 and 120 cm long to allow for passage through the trocar to the surgical site and back out through the same trocar. Shorter lengths are used for intracorporeal knotting to speed knot tying and minimize the amount of suture pulled through tissue. For a simple stitch, the suture length is 10 to 15 cm, with 12 mm added for each additional stitch in a running suture.

Laparoscopic needles come in different shapes: straight, curved, ski-shaped, and canoe-shaped. The straight needle has limited uses and requires a side-to-side pushing motion to advance it through tissues. The advantages of the straight needle are that it is easy to grasp and it passes easily through any port. The ski- and canoe-shaped needles also pass easily through most ports but provide a better approach to the tissue than a straight needle. Furthermore, they curve through an arc with less tension and trauma to tissue. The curved needle provides the most natural passage through the tissue but is somewhat more difficult to load onto needle drivers. Also, larger curved needles may not fit through a given port site and are more likely to get caught up on the inside of a trocar. Sutures on 2-0 or 4-0 tapered needles are most commonly used at our institution and are extracorporeally cut approximately 8 cm for intracorporeal knot tying of an interrupted suture.

The Simple Stitch

Introducing Needle and Suture Into the Body and Loading the Needle Driver

Under most circumstances, the needle and suture can be passed directly through the trocar. To pass the needle, hold the suture with a needle driver or grasper several centimeters behind the swage of the needle. Then open the trapdoor of the trocar with one hand and pass the instrument channel through the trocar, taking care not to tear rubber gasket or valve with the needle. A reducing sleeve may also help to avoid catching the needle and suture on the inner workings of the trocar but is not usually necessary. The limiting factor is the size of the needle; larger curved needles may require a 10-mm instead of a 5-mm port. The largest needles require removing the trocar and actually passing the needle through the port site incision.

Once inside the peritoneum, watch the needle at all times for safety. To grasp the needle, either hold the needle near its tip with the grasper and then grab it with the needle driver or place the needle on a flat surface and pick it up with the needle driver. A good needle driver does the following:

1. Secures the needle with a minimum of readjustment needed
2. Permits multiple angles of alignment
3. Allows wrist supination to finesse the needle through its arc
4. Grasps the suture without fraying or kinking

Self-righting needle holders make it easy to secure the needle initially but usually limit the needle angle in the jaws to 90 or 45 degrees. Newer laparoscopic needle drivers mimic standard needle drivers (Fig. 2–10). The latest laparoscopic devices provide more ergonomic, traditional operation of the needle driver. For instance, the Endopath needle holder (Ethicon Endo-Surgery) is a 5-mm device with two jaw-like handles and a magnetic, self-righting tip that automatically loads any needle at 90 degrees (Fig. 2–11). The in-line handles allow smooth, unfettered wrist supination and fit comfortably in the hand. However, unlike the release of jaws of traditional needle holders at laparotomy, with the Endopath needle holder, a button must be pressed with the index finger to release the clamped jaws. This action can be awkward when the wrist is in the maximally supinated position.

Passing the Stitch

The rule of laparoscopic suturing should be, "Place the stitch perfectly on the first pass." The time it takes to withdraw the needle, reload the needle driver, retract the tissue, and provide countertension for a misplaced stitch makes good preparation especially important in laparoscopic surgery.

With the needle in place in the driver, advance the laparoscope for a close-up of the suture site and use the grasper to present the tissue to the needle tip. As in open surgery, the tip of the needle enters perpendicular to the tissue surface, and the rest of needle gently follows through on its arc. When the tip emerges on the other side, secure it with graspers, release the

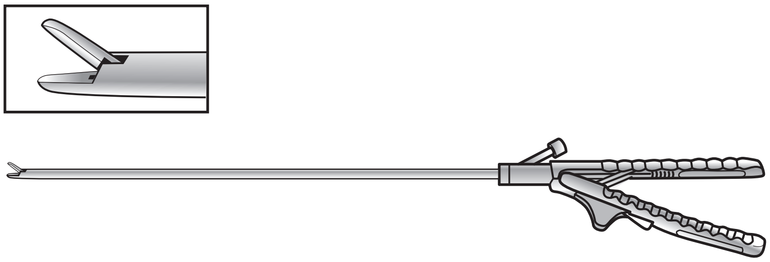

FIGURE 2–10. Standard laparoscopic needle holder (Ethicon, Cincinnati, OH).

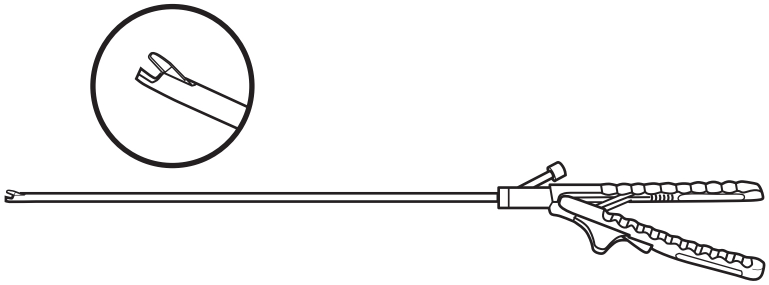

FIGURE 2–11. The Endopath needle holder (Ethicon, Cincinnati, OH) has a self-righting jaw that holds any needle at a 90-degree angle.

FIGURE 2–12. EndoStitch suturing device (U.S. Surgical, Norwalk, CT). *Inset,* Close-up of jaws showing T needle with suture exiting the center of the needle. The surgeon passes the needle from one jaw to the other by tilting a lever on the instrument's handle.

needle driver's jaws, and pull the needle through the rest of its arc. Grasping the needle before releasing the needle driver prevents back-slip of the needle tip into the tissue. Alternatively, instead of securing the needle with graspers, reload the needle farther back on its swage and advance it through the tissue until a decent portion of needle is showing. Then simply grab the needle with the driver to finish the stitch. This latter maneuver avoids the redundancy of grasping the needle twice and takes good advantage of the self-righting feature of many needle drivers.

EndoStitch

EndoStitch (AutoSuture, U.S. Surgical) is an easy-to-use, disposable 10-mm–port suturing device that eliminates the need for a separate needle driver and grasper (Fig. 2–12). It is particularly well suited to performing laparoscopic pyeloplasty. The two jaws of the instrument pass a straight needle with the attached suture back and forth and can be operated with one hand. First, choose the appropriate suture and load it onto the instrument. Next, place the target tissue between the jaws, and squeeze the handles of the instrument to bring the jaws together. This action passes the needle tip through the tissue and into the head of the apposing jaw. Tilt the dark-colored lever located on the handle to endow the receiving jaw with the task of holding the needle, and open the jaws to complete the stitch (see later discussion of suturing). Suture is available in braided synthetic absorbable, braided nylon, braided silk, and braided polyester and ranges in size between 0 and 4-0.

Knot Tying

Laparoscopic knotting is broadly classified as extracorporeal or intracorporeal. Numerous knots and tying techniques have been invented or adapted from other disciplines (fishermen, cowboys, otolaryngologists) for use in laparoscopic surgery. We think that the surgeon must become familiar with two or three extracorporeal knots and one or two methods of tying intracorporeal knots.

Extracorporeal knots generally place more tension on the tissue during tying and pushing of the knot than intracorporeal knots. Also, the 40 to 60 cm of suture that is dragged through the stitch in extracorporeal methods may macerate and saw apart more delicate tissues. A final drawback to extracorporeal knotting is the loss of intracorporeal CO_2 pressure. This loss can be alleviated by the placement of a finger over the trocar mouth while tying the knot. Intracorporeal knot tying is technically more difficult to master and generally requires more time. However, this method is preferred for microsurgical techniques and fine tissues.

Extracorporeal Knotting

The classic extracorporeal knot, the square knot, requires a long suture (80–120 cm). After passing the needle through the tissue, grab the suture with the needle driver just behind the needle and withdraw it from the trocar. At this point, both ends of the suture lie outside the patient's body. Form alternating half-hitches and advance them individually to the tissue with a knot thrower (Fig. 2–13). Take care to throw alternating hitches in opposite directions to ensure a true square knot. Next, secure both strands in one hand and keep tension on the free ends while advancing the pusher. Throwing a surgeon's knot on the first hitch will help maintain appropriate tissue tension while the second half-hitch is being formed. Tying multiple half-hitches at once, but advancing them one at a time (to avoid an air knot), may save time and prevent loss of CO_2.

A second popular and trustworthy extracorporeal knot is the locking Roeder slipknot (see earlier description of loop ligation and Fig. 2–8). The advantage of the Roeder knot over the square knot is that the entire knot is formed outside the body and advanced in a single throw to complete the stitch. This

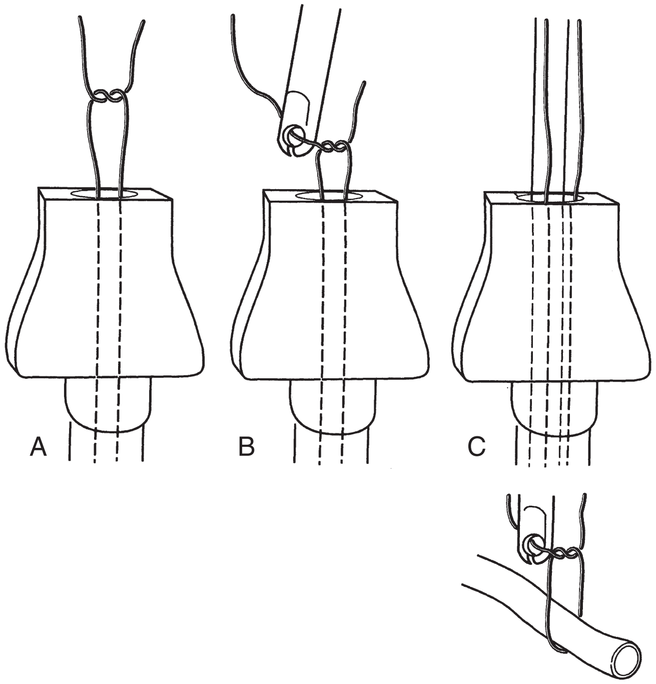

FIGURE 2–13. Tying an extracorporeal knot. *A,* Half-hitch is thrown. *B,* Both free strands are secured in one hand, and the knot pusher is used to advance the knot. *C,* While the throw is being advanced, the knot pusher applies pressure on the strand, and not directly over the knot.

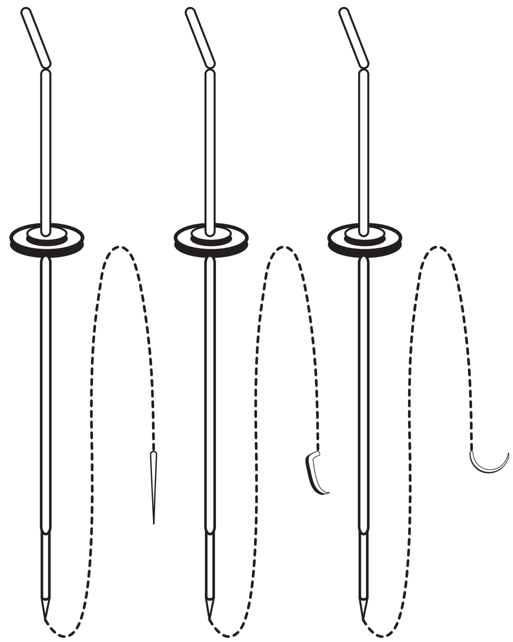

FIGURE 2–14. Surgiwip sutures (U.S. Surgical, Norwalk, CT). Three different needle configurations and suture come with a preloaded knot pusher and reducing sleeve. Once the knot is tied, the surgeon snaps the tip off the knot pusher and pulls back on the suture, while advancing the pusher to cinch the knot.

feature may be particularly useful for approximating tissues under tension. Although the standard Roeder knot takes 20 to 30 seconds to tie, the total time needed to complete the simple interrupted stitch is not longer than when using the square knot. The suture must be long enough to allow both ends to lie outside the body after the needle has been passed through the defect. First, form a simple half-hitch 4 to 6 inches above the mouth of the trocar, and pinch it between two fingers. An assistant places a finger over the trocar mouth to prevent loss of CO_2. Next, wrap one of the suture ends around the two strands several times: a minimum of three passes is required for braided and gut suture; five to seven passes are needed for monofilament suture. The knot is finished by either (1) passing the free end of the suture through the two strands and cinching it tight or (2) wrapping the free end around one of the strands and then bringing the end back up through the first loop formed below the half-hitch. Use a knot thrower to advance the knot down to the tissue, as previously described for the square knot. Another half-hitch or two can be thrown on top of this knot for maximum security.

The EndoSuture and Surgiwip (U.S. Surgical) systems simplify the knotting process by providing suture with a preloaded knot pusher. This saves the step of picking up a reusable knot pusher and positioning it on the suture. In the EndoSuture system, the small disposable knot pusher and suture are loaded onto a reusable metal handle, which then functions as the knot pusher after the knot is tied extracorporeally in the usual fashion. The Surgiwip system functions much like the Surgitie loop ligature discussed previously: The proximal tip of the plastic knot pusher is snapped off, and the attached suture is pulled to advance the knot while the knot pusher is advanced. Straight, curved, and ski-shaped needles with a variety of suture materials and sizes are available with this system (Fig. 2–14).

Intracorporeal Knotting

SQUARE KNOT. There are many variations on this basic surgeon's square knot (smiley face, triple twist, rotational [Roeder-like]), but the sequence described here suffices for most procedures. The knot is akin to the open surgical instrument tie (Fig. 2–15*A* to *D*) and needs to be part of every laparoscopic surgeon's arsenal. The ability to convert a square knot to a sliding knot is a useful skill for approximating tissues under tension (see Fig. 2–15*E* to *H*). After creating the slipknot, slide it into place on the tissue and convert it back to a square knot, then pull it tight. Add additional half-hitches to complete the knot, and cut the sutures to leave 6-mm tails.

ENDOSTITCH. After placing a simple stitch with this suturing device, as described previously, the jaws may be closed and the instrument drawn back through its 10-mm port to tie an extracorporeal knot. This approach, however, limits the surgeon to one stitch per load (about $25 to $30 per load). An intracorporeal knot is preferred for multiple interrupted stitches or a running suture line. Briefly, pass the needle between the jaws of the EndoStitch, and use a grasper to lay the free end of suture between the two jaws (Fig. 2–16*A* and *B*). Next, pass the needle back to the original jaw (see Fig. 2–16*C*), and pull the suture through the loop to create the first half-hitch (see Fig. 2–16*D* and *E*). Repeat this sequence several times to throw subsequent half-hitches and complete the knot.

Running Suture

Starting the Running Stitch

The running suture line may be started with any of the simple stitches and devices described previously, including the Endo-

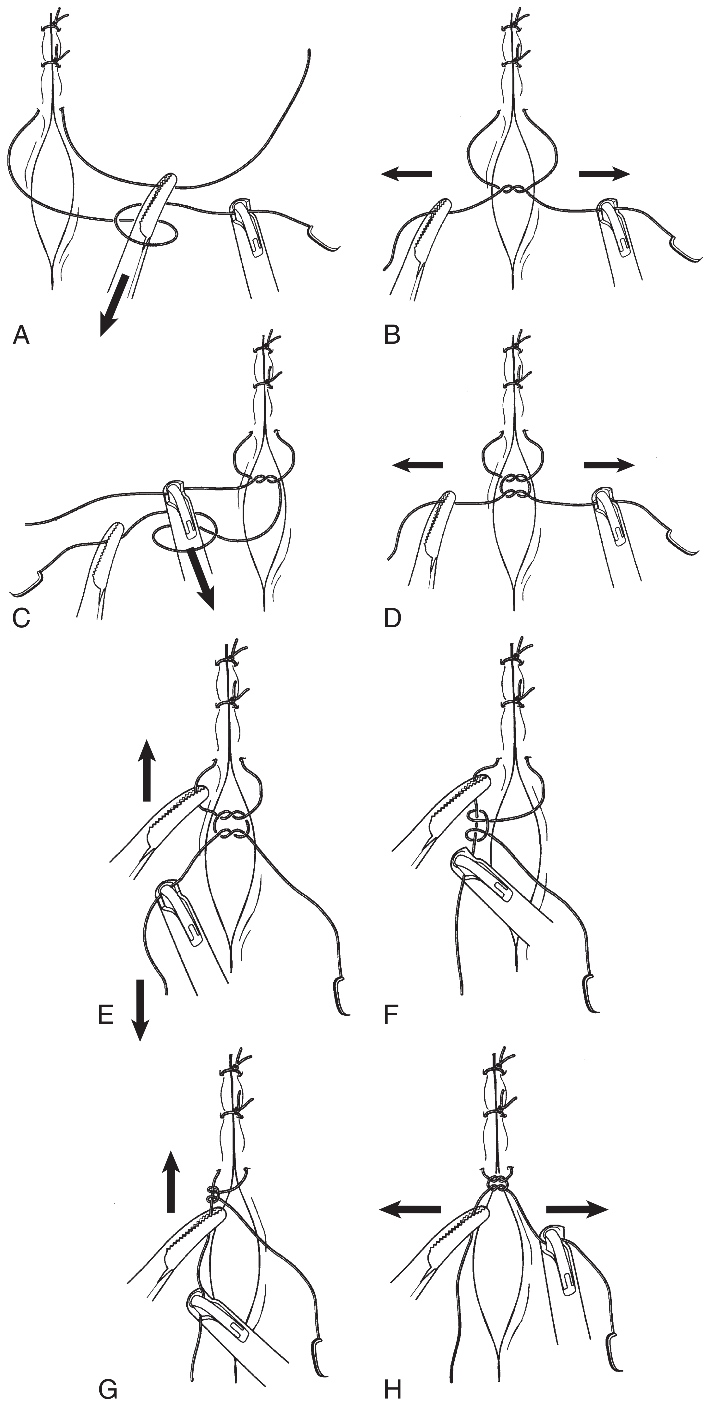

FIGURE 2–15. Intracorporeal square knot. *A–D,* Instrument tie formation of a square knot. *E–H,* Conversion of a square knot into a sliding knot. The ability to perform this conversion is useful to avoid throwing intracorporeal "air knots."

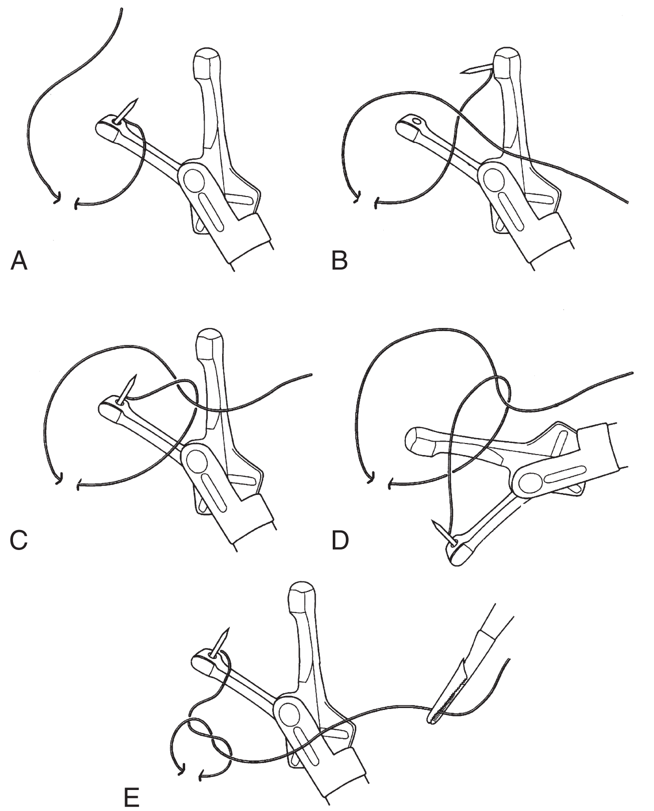

FIGURE 2–16. Intracorporeal knot tying using the EndoStitch device (U.S. Surgical, Norwalk, CT). *A,* Stitch is placed. *B,* Device handle is squeezed to close its jaws, and the needle is passed to the other side. A grasper is used to lay the free end of the suture between the device's jaws. *C,* Needle is again passed to the other jaw. *D,* Jaw is pulled with the needle and suture through the loop to create the first half-hitch. *E,* Countertension is applied with the grasper and the EndoStitch to advance the throw toward the tissue.

Stitch and the Suture Assistant, as long as the suture end with needle is long enough for the task. Creating a jamming loop knot (Dundee knot) on the end of a suture is another way to start a running suture line (Fig. 2–17). (A Roeder knot is also acceptable for forming an end loop but takes longer to tie in this circumstance.)

Place the needle and suture with loop into the abdomen and grasp the needle with the needle driver. After passing the needle through the tissue, pull the suture through until the loop on the end of the suture abuts the tissue. Then pass the needle and suture back through the loop and tighten down the slipknot.

Another useful tool for starting and finishing running sutures is the Lapra-Ty absorbable suture clip applier (Ethicon, Cincinnati, OH) (Fig. 2–18). Instead of tying a knot, a special clip is applied to the suture, anchoring it in place. This device is reusable (nondisposable), uses a 10-mm port, and comes with clips for use with 2-0, 3-0, and 4-0 coated Vicryl suture. When choosing suture for a running stitch, allow an extra 10 to 15 mm for each stitch and 10 cm more for tying a knot at the end of the line. When sewing toward oneself, place the first stitch 2 to 3 mm distal to the defect.

Sewing

Once the first anchoring stitch is placed, place additional stitches as when closing a wound during an open procedure. The EndoStitch is well designed for this task, eliminating the cumbersome task of reloading the needle after each pass (Fig. 2–19). Locking sutures may help keep tension on the suture line. Continue stitching 2 to 3 mm past the end of the defect and then prepare to finish the running suture.

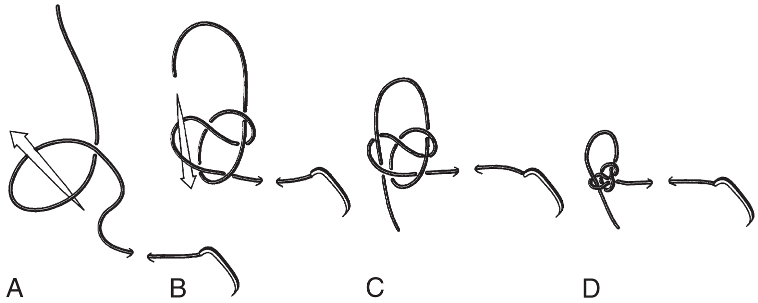

FIGURE 2–17. The jamming loop knot (Dundee knot), tied extracorporeally, is used to create a loop near the end of the suture for use in a running stitch. Make a small loop near the end of the suture *(A)* and pass a second loop through the first loop *(B)*. Next, pass the free end of suture through the second loop *(C)* and cinch tight *(D)*.

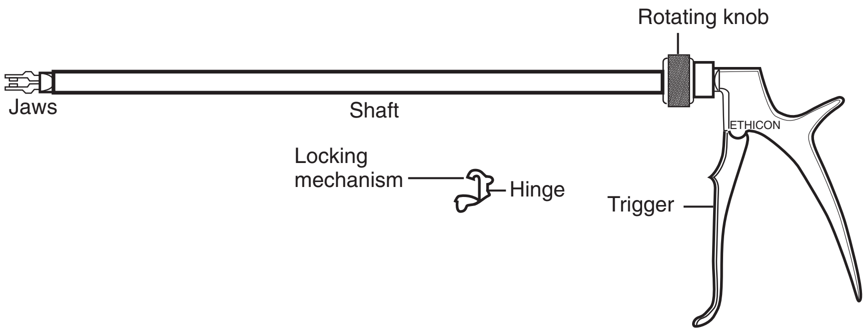

FIGURE 2–18. Lapra-Ty absorbable suture clip applier (Ethicon, Cincinnati, OH). The base unit is reusable and fits through a 10-mm port. The clip is hinged, as shown in the drawing, and locks when the handles are squeezed together.

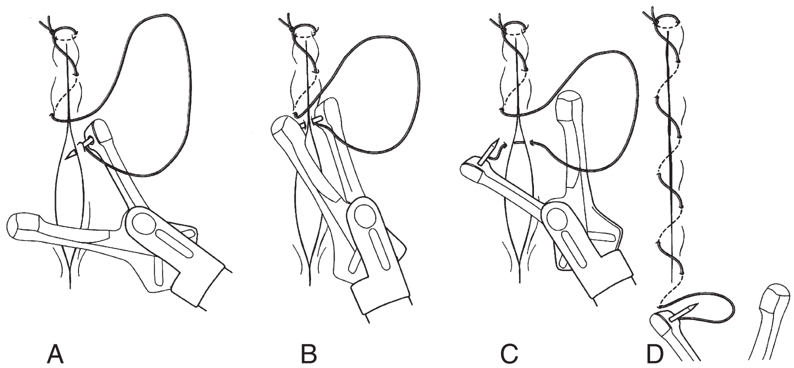

FIGURE 2–19. Running suture with the EndoStitch device (U.S. Surgical, Norwalk, CT). *A,* The first stitch is placed 2 to 3 mm distal to the defect, and the knot is placed. *B* and *C,* The needle is passed between the two jaws through the tissue to perform the actual suturing. *D,* The suture line is continued 2 to 3 mm past the end of the defect, with tension maintained on the end suture. The stitch is finished with a suture clip (see Fig. 2–20) or Aberdeen knot (see Fig. 2–21).

Terminating the Running Stitch

As previously mentioned, the Lapra-Ty absorbable clip applier was designed to place clips on suture in lieu of tying a knot. To use this instrument at the end of a running stitch, pull the free end of suture taut with a grasper and place a clip on the suture just where it exits the tissue (Fig. 2–20). Then cut the suture free, leaving an 8- to 12-mm tail, and remove the needle from the body. This method is simple, fast, and easy to learn.

The alternative to clipping the suture is tying a knot at the end. The favored knot for this purpose is the Aberdeen (Fig. 2–21) because it causes the least amount of trauma to the suture and is less likely to loosen. The Aberdeen knot is technically challenging because a fair amount of practice is required to become adept at tying the knot while maintaining tension on the suture.

LAPAROSCOPIC NEPHROPEXY

Nephropexy remains an uncommon operation yet represents a technically feasible reconstructive renal procedure for the laparoscopic surgeon. For the purpose of this chapter, nephropexy illustrates several important reconstructive techniques and requires the use of laparoscopic suturing. The use of new technology simplifies suturing of the kidney to the abdominal wall fascia.

Indications

Nephroptosis is characterized by a significant downward displacement (>5 cm) of the kidney when the patient moves from supine to erect position. The pain of nephroptosis is thought to be from either renal ischemia or renal obstruction. Symptomatic nephroptosis represents the primary clinical indication for nephropexy.

Preoperative Evaluation and Preparation

Intravenous urograms or renal scans in erect and supine positions are the best diagnostic studies for nephroptosis. Either obstruction or diminished flow to the symptomatic side is expected. Standard blood tests, chest radiograph, electrocardiogram, and oral bowel preparation with magnesium citrate are

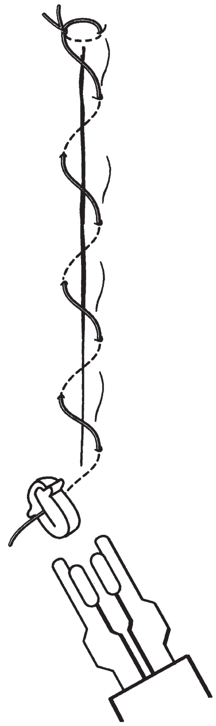

FIGURE 2–20. Lapra-Ty (Ethicon Endo-Surgery, Inc., Cincinnati, OH) used to finish a a running suture without a knot.

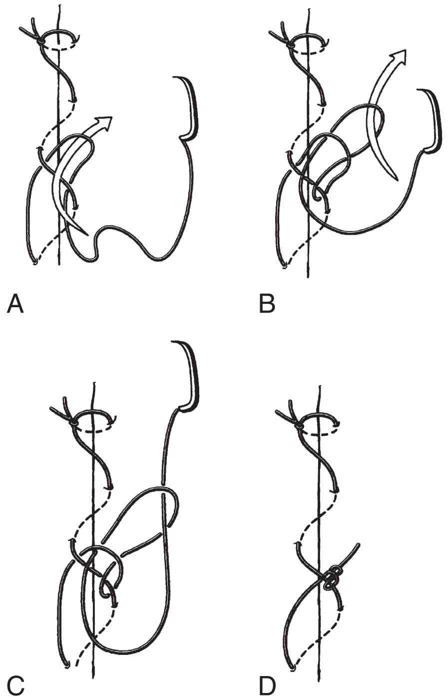

FIGURE 2–21. Aberdeen knot to finish a running suture.

performed the day before surgery. The patient is admitted to the hospital the day of surgery.

Patient Positioning

We prefer lateral insufflation to establish pneumoperitoneum, and we position the patient in the modified lateral position.

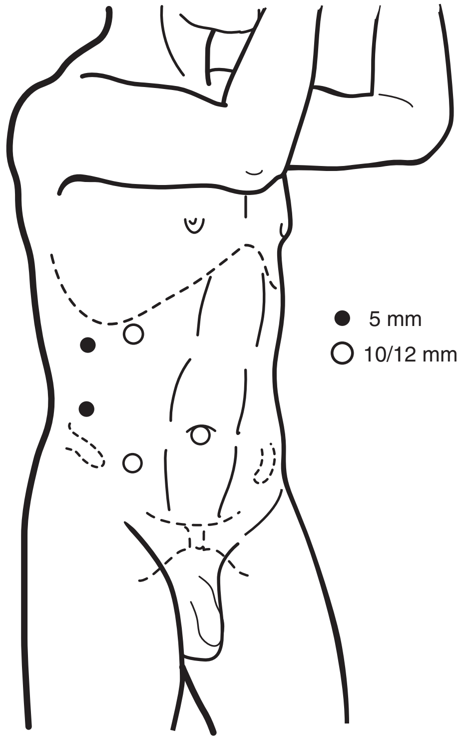

FIGURE 2–22. Port placement and patient positioning for laparoscopic nephropexy. With the patient in lateral position, five ports are typically used: two axillary ports, two midclavicular line ports, and an umbilical port.

We typically use five laparoscopic ports when performing laparoscopic nephropexy. The camera is placed at the umbilicus, and two midclavicular line (MCL) ports and two anterior axillary line ports are used (Fig. 2–22). The port configuration may vary according to the anatomy of the patient. Typically, patients with nephroptosis are thin and have a minimum of retroperitoneal fat, a feature that usually simplifies the dissection.

Procedure

Incise the line of Toldt by means of a grasper and dissecting scissors through the MCL ports. The colon is reflected medially, exposing the kidney in the retroperitoneum. Medially retract the colon with a Jarit retractor, and stroke the colonic reflection with a closed grasper to enter and open up the correct plane.

Incise the peritoneal reflection and Gerota's fascia over the kidney anteriorly in a T configuration with the dissecting scissors and graspers through the MCL ports (Fig. 2–23*A*). The kidney is fully mobilized by freeing its lower, lateral, and posterior attachments with the dissecting scissors or hook electrode (see Fig. 2–23*B*). Use the Jarit retractor to facilitate retraction of the kidney, if needed. Take care to fulgurate all small perforating vessels, and strip the perirenal and pararenal fat from the renal capsule. These two steps will facilitate scar formation and improve fixation of the kidney.

Once cleared, the fascia overlying the quadratus lumborum and psoas muscle is easily exposed. Through the MCL ports, laparoscopically place a series of interrupted sutures between

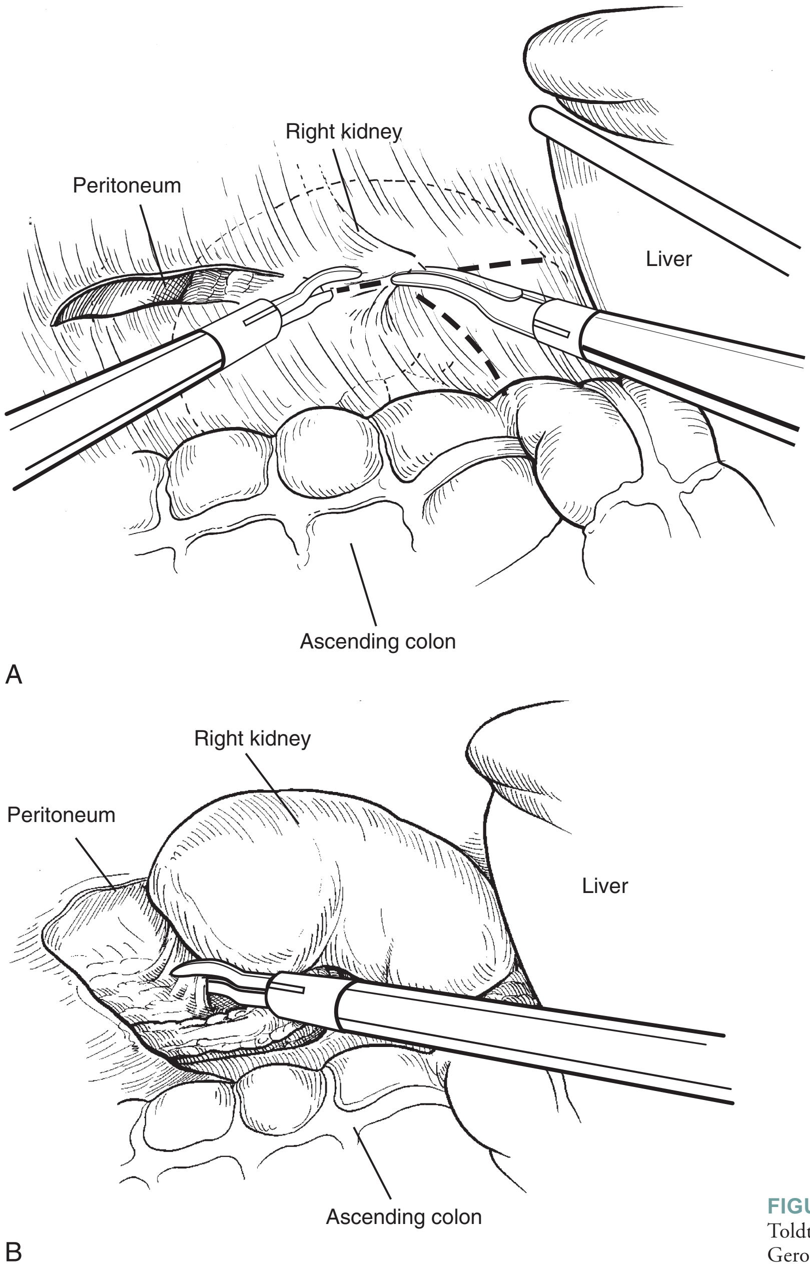

FIGURE 2–23. The kidney is exposed (*A*) by dividing the line of Toldt and medial reflection of the colon and (*B*) stripping the overlying Gerota's fascia down to the capsule.

the lateral edge of the kidney and the fascia overlying the abdominal wall musculature (Fig. 2–24). Use nonabsorbable 2-0 sutures, and place them with the Suture Assistant, extracorporeal knots, or Lapra-Ty clips as described earlier. Take care to place the sutures in the capsule and not into the collecting system. We place four to six sutures in the upper to lower lateral border of the kidney. The number of sutures needed will vary with the size of the kidney. The subhepatic parietal peritoneum may also be sutured to the anterior portion of the renal capsule to provide additional support for the kidney if feasible. Newer alternatives, including the use of fibrin glue (see later discussion), may someday further simplify this procedure.

Bring down the pneumoperitoneum to a pressure of 5 mm Hg, and carefully inspect for any bleeding along the suture lines. Close all ports under endoscopic guidance, and close skin sites with subcuticular sutures. No drains are used.

Postoperative Considerations

Follow routine postoperative management. Aside from clinical assessment, perform erect and supine diuretic renography or intravenous urography 6 to 8 weeks after surgery to assess drainage.

FUTURE DIRECTIONS

Although much of this chapter has been devoted to espousing the latest laparoscopic techniques available for suturing and reconstruction of the urinary tract, the future of reconstructive

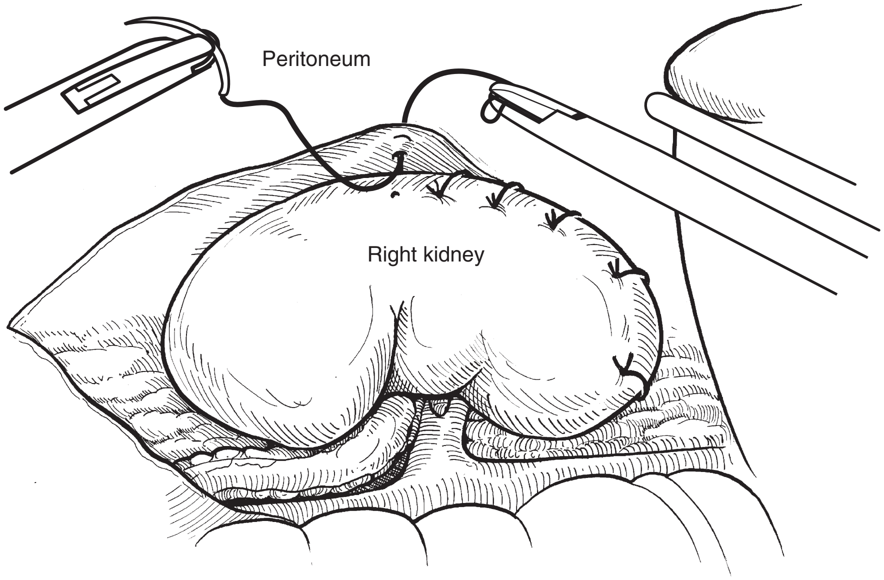

FIGURE 2–24. Laparoscopic suturing reapproximates the abdominal wall fascia to the renal parenchyma.

laparoscopy may be more technology based. Laparoscopic reconstruction may follow the lead of hemostasis and tissue dissection by simplifying reconstruction through automation and new technology. In the era of nephron-sparing surgery, the most innovative reconstructive alternatives available at the time of this writing are in the area of fibrin and thrombin glue products for maintaining hemostasis during laparoscopic partial nephrectomy.

Fibrin Glue

Fibrin glue has been described as an adjunct for laparoscopic reconstruction, as a sealant for use in trauma, and as a hemostatic adjunct in laparoscopy.[5–7] Fibrin glue is made from the combination of fibrinogen and thrombin. The thrombin is prepared either from autologous or pooled plasma, and the fibrinogen is typically cryoprecipitated. It is conceivable that fibrin glue could be used as an adjunct to laparoscopic reconstruction in two ways: (1) as a sealant to hasten sutured anastomoses and (2) as a replacement for sutured anastomoses. Studies have shown that fibrin glue, when used alone during tubular anastomoses, may cause problems.[8] Other investigators have demonstrated a significant time savings when fibrin glue is used as a sealant after several interrupted stay sutures are placed, in particular for complex procedures such as laparoscopic pyeloplasty and ureteroureterostomy.[9] It appears that present trends in laparoscopic suturing technology favor automated placement of interrupted sutures, which should lend itself to the use of fibrin sealants.

Thrombin Glue

The use of thrombin glue has been a useful adjunct to traditional reconstructive measures in maintaining hemostasis during laparoscopic partial nephrectomy. FloSeal (Baxter Healthcare Corporation, Fremont, CA), a hemostatic matrix, is neither a sponge nor a fibrin glue but a proprietary combination of specially engineered collagen-derived particles and topical thrombin. Ready for use in just 2 minutes, it can be applied to virtually any bleeding structure and remains in place even on irregular anatomy, allowing a quick return to the surgical procedure. FloSeal hemostatic matrix is applied to the tissue surface at the base of the lesion where the granules fill the wound and conform to its shape. The granules swell approximately 20% within 10 minutes of application and restrict the flow of blood. Blood percolates through the spaces and is exposed to high concentrations of thrombin. Thrombin converts fibrinogen into fibrin polymer, which forms a clot around the mechanically stable matrix provided by the granules. FloSeal takes 2 minutes to prepare, without the need for a mixing device as is required with fibrin glue products.

The use of FloSeal has been instrumental in maintaining hemostasis during laparoscopic partial nephrectomy at our institution. The application is easy and may be performed through a 5- or 10-mm port. The technique of laparoscopic partial nephrectomy is described elsewhere in this atlas.

Briefly, following confirmation of adequate tumor excision during laparoscopic partial nephrectomy, we generally apply FloSeal to the defect through a 10-mm port (Fig. 2–25). Next, we introduce the suture to close the defect through a 10-mm port with a Lapra-Ty attached extracorporeally at one end. After throwing a stitch on one side of the renal capsule, we place a surgical bolster in the defect (over the glue) and secure it with a second throw of the suture. A second Lapra-Ty is applied after the suture is cinched up (Fig. 2–26).

The delivery of the fibrin or thrombin glue continues to evolve. It is hoped that the availability of brushes for microsurgical application of fibrin glue will supersede the makeshift syringes, catheters, and tubing currently used for most laparoscopic applications.[10] Automated delivery devices preloaded with ready-to-mix fibrin and thrombin sealants will simplify application for the busy reconstructive laparoscopic surgeon.

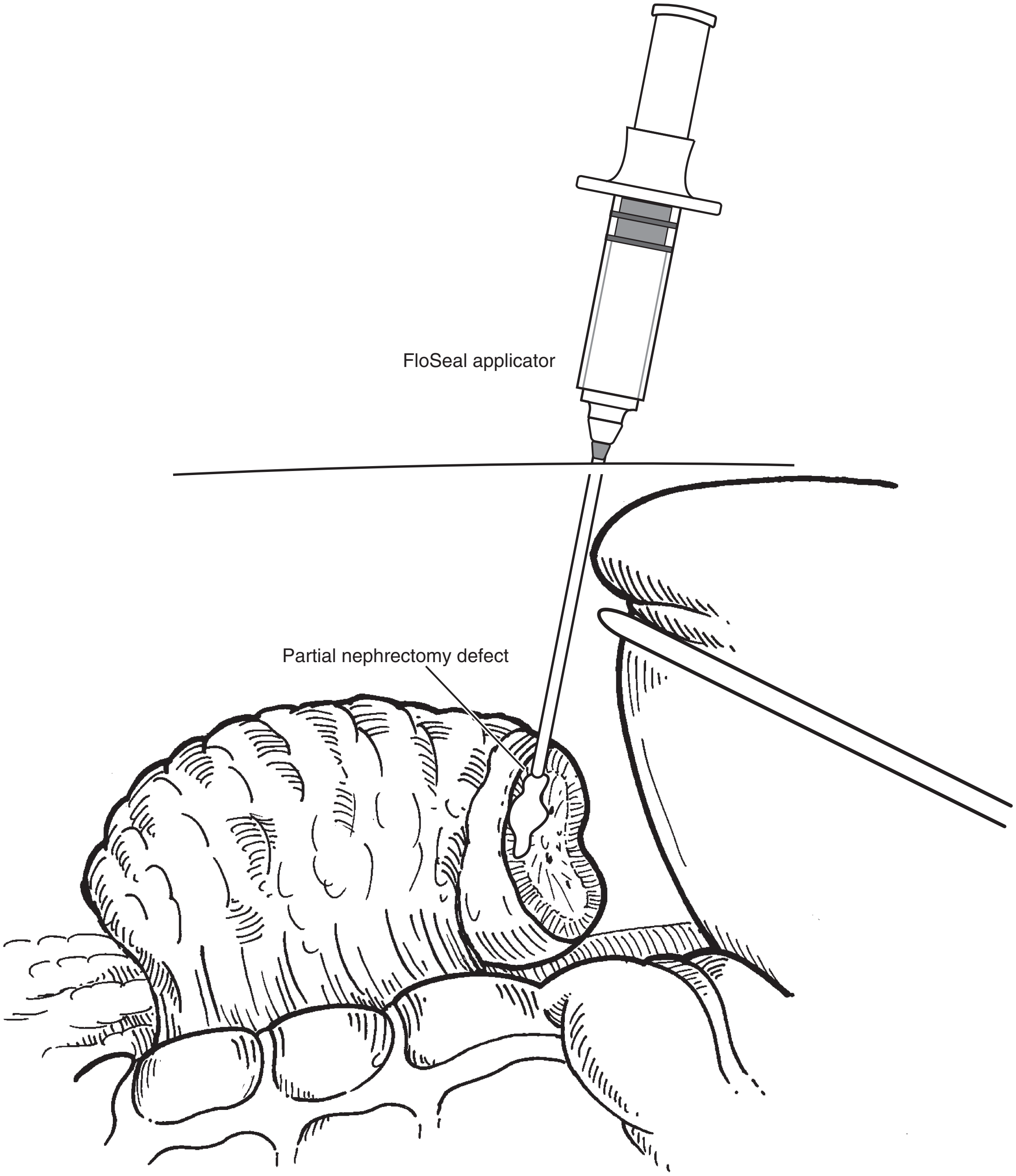

FIGURE 2–25. FloSeal (Baxter Healthcare Corporation, Fremont, CA) applied for hemostasis after removal of tumor during laparoscopic partial nephrectomy.

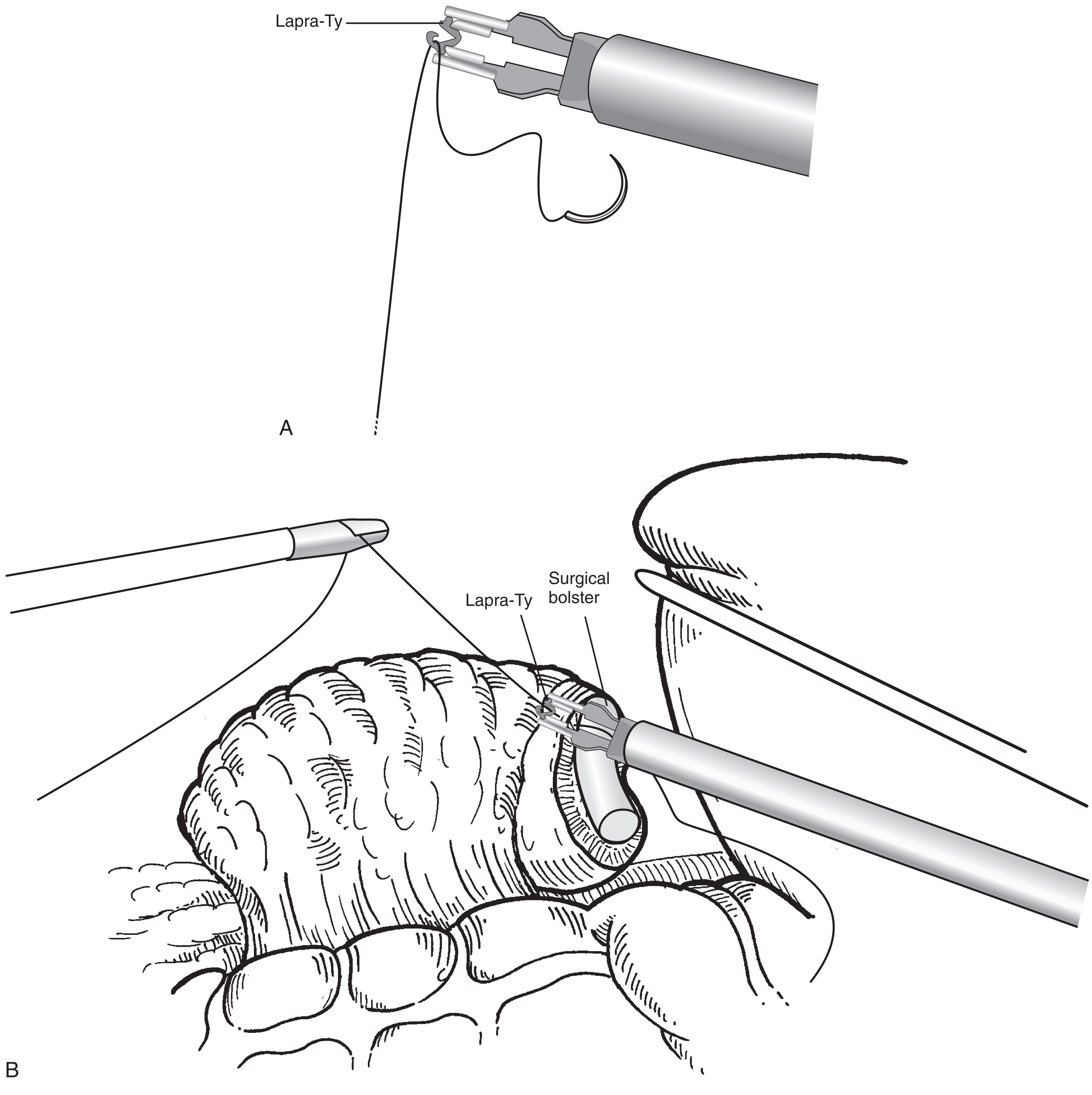

FIGURE 2–26. *A,* Laparoscopic suturing to close the defect during laparoscopic partial nephrectomy. The suture is introduced through a 10-mm port with a Lapra-Ty on one end. After a stitch is thrown on one side of the renal capsule, a surgical bolster is placed in the defect and secured with a second throw of the suture. *B,* Lapra-Ty clip applier (Ethicon, Cincinnati, OH) places the second absorbable clip on the suture to tighten the suture and to secure the free end.

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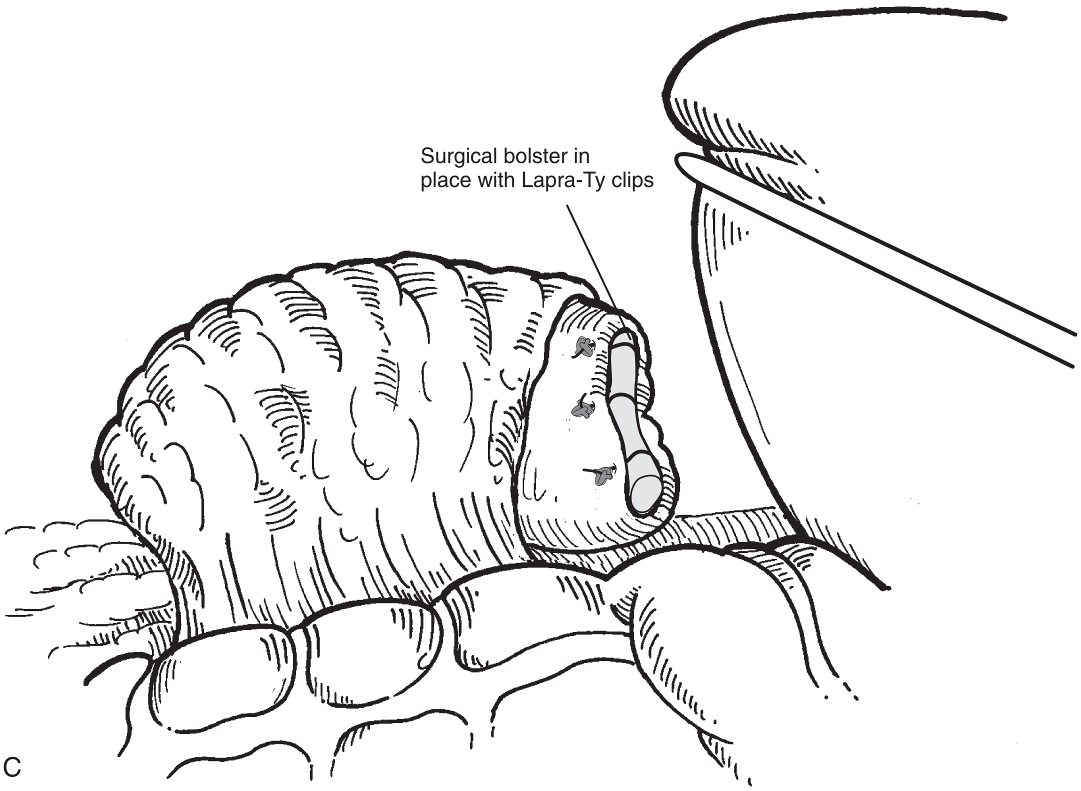

FIGURE 2–26, cont'd. *C,* The tightened sutures with Lapra-Ty clips secure the bolster in place and result in hemostasis at the cut surface of the kidney.

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Anesthetic Implications of Minimally Invasive Urologic Surgery

Ian H. Black
Kurt W. Grathwohl

The primary anesthetic goals for minimally invasive surgery follow:

1. Patient safety
2. Avoidance or early treatment of pathophysiologic changes associated with laparoscopy
3. Amnesia
4. Analgesia during the entire perioperative period
5. Ideal surgical field (muscle relaxation, position, and so on)
6. Rapid recovery
7. Therapy for adverse effects of anesthesia (nausea and vomiting)

The aim of this chapter is to review and enhance the anesthesiologists' and surgeons' appreciation of the unique anesthetic-related implications of minimally invasive urologic surgery to improve communication and patient safety.

Laparoscopy has become increasingly more common because of reduced postoperative pain, shortened convalescence, decreased hospitalization, and significant cost savings.[1–4] Initial enthusiasm for some laparoscopic procedures has sometimes been tempered by the findings of larger studies of either no or minimal differences in outcomes compared with other techniques.[5,6] Despite improved outcomes and the minimally invasive title, laparoscopy can be associated with major cardiopulmonary perturbations and anesthetic-related complications (Table 3–1), resulting in significant challenges to the anesthesiologist, surgeon, and patient. Successful laparoscopy mandates a knowledgeable anesthesiologist and communication with the entire surgical team.

In addition, the scientific literature detailing anesthetic challenges during laparoscopy is incomplete. The largest laparoscopic series come from gynecologic procedures and cholecystectomies. Outcomes and complications may or may not be generalized to minimally invasive urologic procedures depending on what outcomes are examined. A large multi-institutional series of 2407 laparoscopic urologic procedures showed complication rates comparable to those of other surgical procedures,[7] whereas a study of laparoscopic nephrectomies showed an increase in serum catecholamines in the laparoscopic group compared with the open group.[8] This difference was not seen in laparoscopic cholecystectomies.[9,10] Older studies evaluating complications from laparoscopy in which intra-abdominal pressures (IAPs) greater than 20 mm Hg were used may not be generalizable to today's procedures, which use lower IAPs.

The types of laparoscopic procedures and patient indications are also growing as technologies enhance the surgeon's abilities to perform these operations. In fact, the U.K. Department of Health predicted that 70% to 80% of surgical procedures would be performed endoscopically.[11] Consequently, laparoscopy is performed on elderly, pediatric, pregnant, and obese patients as well as those with significant comorbid diseases and entails all the anesthetic risks that usually accompany these groups.

Studies evaluating anesthetic-related complications of newer minimally invasive laparoscopic surgery indicate the incidence is extremely low.[1,7] Rose and colleagues[12] reported anesthetic-related complications of laparoscopic cholecystectomy, noting considerable perioperative morbidity consisting of hypotension (12.9%), postanesthetic care unit hypothermia (31.4%), nausea and vomiting (12.9%), and O_2 desaturation (10.9%). These minor anesthetic complications occur at a higher frequency than major surgical complications. Large series of laparoscopic cholecystectomies report bowel perforation (2 in 1000) and major hemorrhage (2–9 in 1000) as the most common serious complication.[13] Intestinal injuries account for a large percentage of complications and are often discovered in the postoperative period. Complication rates can change considerably depending on both surgeon and institutional experience and the complexity of the case. An institution that began performing laparoscopic radical cystectomy had more than a third of patients (4 of 11) experiencing complications that either were directly attributable to laparoscopy or required conversion to an open technique.[14] In one study,[15] postoperative anesthetic-related complications included congestive heart failure (n = 3), atrial fibrillation (n = 2), myocardial infarction (n = 1), pneumonitis (n = 2), pulmonary embolism (n = 1), brachial nerve palsy (n = 1), lateral compartment syndrome (n = 1), nonoliguric acute tubular necrosis (n = 1), and mental status changes (n = 1). In 1993, Kavoussi and associates[16] evaluated 372 laparoscopic pelvic lymph node dissection patients at eight medical centers and found anesthetic-related complications in nine cases (2.4%): hypercarbia (n = 1), prolonged sedation (n = 1), obturator nerve palsy (n = 2), and lower extremity deep venous thrombosis (n = 5). There were no deaths reported in their series.[15,16]

INDICATIONS AND CONTRAINDICATIONS

Pneumoperitoneum after peritoneal insufflation and alterations in patient position cause several physiologic effects unique to laparoscopy. Hemodynamic changes during brief procedures in healthy patients are minimal; however, patients with preoperative cardiopulmonary disease demonstrate significant pathophysiologic changes.[11,17–19]

TABLE 3–1. ANESTHETIC CHALLENGES OF LAPAROSCOPIC SURGERY

Intraoperative
Gastroesophageal reflux/aspiration pneumonitis
Positioning-related nerve injury
Positioning-related physiologic effects
Hemorrhage from vascular injury
Fluid therapy overload
Hypothermia
Associated With Insufflation/Pneumoperitoneum
Vagal response
Cardiac arrhythmias
Hypercarbia
CO_2 and gas embolism
Emphysema (subcutaneous, preperitoneal)
Pneumothorax, pneumomediastinum, pneumopericardium
Hypotension
Hypertension
Elevated peak airway pressures
Hypoxemia
Oliguria
Postoperative
Nausea and emesis
Abdominal and shoulder pain
Pulmonary impairment

TABLE 3–2. CARDIOPULMONARY RESPONSES TO PNEUMOPERITONEUM LESS THAN 25 mm Hg

Heart rate	↑↔
Stroke volume	↓
Mean arterial pressure	↑
Systemic vascular resistance	↑
Cardiac output	↓
Central venous pressure	↑
Functional residual capacity	↓
Respiratory compliance	↓
Peak airway pressures	↑
Pao_2	↓↔
$Paco_2$	↑
pH	↓↔

↑, increase; ↓, decrease; ↔, no change.

Relatively high solubility and lack of combustion make CO_2 the most common gas used for peritoneal insufflation, although nitrous oxide (N_2O) or helium (He) can be used.[20] CO_2 is also highly permeable, approximately 20 times that of O_2. Peritoneal insufflation pressures of 10 to 25 mm Hg and pure CO_2 at atmospheric pressure (760 mm Hg) create a large gradient for CO_2 diffusion into the bloodstream (CO_2 partial pressure 40 mm Hg). Most of the transperitoneally absorbed CO_2 is converted to bicarbonate for transportation in the blood until the oxidation of hemoglobin causes CO_2 to be released in the alveolar capillaries and expired. Absorption of CO_2 causes an increased arterial pressure of CO_2 ($Paco_2$). $Paco_2$ is directly related to CO_2 production (Vco_2). Vco_2 is the sum of metabolic CO_2 and absorbed CO_2. $Paco_2$ is inversely related to alveolar ventilation (V_A). This is summarized by the equation $Paco_2 = 0.863(Vco_2)/V_A$. Alveolar ventilation is determined by total minute ventilation (V_E) minus dead space ventilation (V_D). Therefore, the net effect of insufflation without a change in alveolar ventilation is an increase in $Paco_2$. The average increase in $Paco_2$ in laparoscopy of less than 30 minutes was 11 mm Hg.[21,22] This rise in $Paco_2$ plateaus in 15 to 30 minutes. A continued rise necessitates a search for the cause to include hypermetabolic states and subcutaneous emphysema. Patients typically demonstrate mild respiratory acidosis, which can be easily corrected with increasing the V_E by 10% to 25%. The elevation of $Paco_2$ is unpredictable in patients with cardiopulmonary disease, secondary to ventilation-perfusion mismatch.[21]

CO_2 acts directly to inhibit the cardiovascular system, decreasing heart rate, cardiac contractility, and systemic vascular resistance while increasing pulmonary artery pressures.[11,23] Stimulation of sympathetic nervous system efferents and increased circulating catecholamines from the adrenal medulla caused by CO_2, however, result in an increase in heart rate, cardiac contractility, and systemic vascular resistance with the result of net increases in cardiac output (CO) and blood pressure.[21,24] Cardiac arrhythmias can be seen with hypercarbia, although arrhythmias are not correlated with $Paco_2$ and may develop early during insufflation.[25]

There are several mechanical effects of increased IAP from pneumoperitoneum. Compression of the abdominal aorta contributes to an increased systemic vascular resistance (SVR) and increased afterload, which can result in decreased CO.[11,24] Venous compression likewise results in decreased CO secondary to an initial increase in venous return to the heart followed by a significant decline in inferior vena cava flow and reduced cardiac preload.[26] Cephalad shift of the diaphragm increases intrathoracic pressures resulting in elevated central venous pressures. Heart rate is also increased by IAP independent of CO_2.[25] Cephalad elevation of the diaphragm by IAP also results in several pulmonary effects, including decreased functional residual capacity and respiratory compliance, as well as increased pulmonary dead space, shunt, and peak airway pressure.[21,24,27] These effects are magnified or may be altered with the administration of anesthetic, in obese patients, and lateral decubitus and Trendelenburg positions, although the contribution of position is now debated.[27–29] The effects of position may be attenuated by peritoneal insufflation in the supine position prior to movement into Trendelenburg or reverse Trendelenburg positions.[28,29] As a consequence of these combined cardiopulmonary changes oxygenation may worsen, although it is typically easily increased by raising the inspired O_2 concentration.[25,28,29] Table 3–2 summarizes the cardiopulmonary effects of IAP; alterations are dependent on several patient and surgical interactions such as the chosen anesthetic, preoperative fluid balance, position, degree of IAP, and type and duration of procedure. Furthermore, patients with underlying cardiopulmonary diseases may display accentuated responses to the laparoscopically induced physiologic changes.[11,21,22]

In addition, increased IAP and resultant cardiovascular changes cause several regional circulatory and endocrine aberrations. Elevated CO_2 and IAP increase cerebral blood flow and intracranial pressure (ICP), although the clinical significance is not clear.[11,30] Splanchnic perfusion and hepatic blood flow are decreased resulting in gastric mucosal hypoperfusion.[11] Neurohumoral factors such as increased antidiuretic hormone (ADH) and vasopressin and mechanical compression of the renal arteries and veins decrease renal blood flow, glomerular filtration rate (GFR), sodium excretion, and creatinine clearance.[11,26] Finally, decreased lower limb venous flow has been speculated to increase risk of deep venous thrombosis (DVT), although data are confounding.[11,16]

Helium peritoneal insufflation has been used to prevent the adverse physiologic sequelae of hypercarbia in patients with severe pulmonary disease and pheochromocytoma.[31,32] The lower solubility of helium, which may theoretically worsen the outcome of venous gas embolism, limits its use.[20,32]

PATIENT PREOPERATIVE EVALUATION AND PREPARATION

The potentially severe cardiopulmonary changes associated with minimally invasive surgery make it imperative that a thorough preanesthetic assessment is performed on every patient. Even though laparoscopy is not contraindicated in obesity, extremes of age, pregnancy, and those with severe cardiopulmonary disease, it is important to ensure that the patient is medically maximized in order to safely tolerate the physiologic changes. Moreover, the potential for conversion to an open procedure necessitates that the patient be counseled appropriately and is medically ready to tolerate the surgical stress associated with these procedures. Guidelines for preoperative assessment have been outlined and should be adhered to.[33] The preoperative evaluation allows the anesthetist to properly plan perioperative management and decrease patient anxiety. It is estimated that reductions in unnecessary laboratory tests, operating room delays, cancellations, and “no shows” account for savings of approximately $50 per patient even when the cost of the preoperative clinic is taken into consideration.[34]

Practice guidelines for preoperative fasting and the use of pharmacologic agents to reduce the risk of pulmonary aspiration have been published and, as with all surgical procedures, should be adhered to.[35]

The perioperative evaluation and management of patients with pheochromocytoma are well known and should not be different for laparoscopic adrenalectomy of pheochromocytoma. Increased release of catecholamines during anesthesia and tumor manipulation may exacerbate the pathophysiologic effects of CO_2-induced pneumoperitoneum, although reports have been conflicting.[31,36,37]

OPERATING ROOM CONFIGURATION AND PATIENT POSITIONING

Monitoring Considerations

Routine intraoperative monitoring should include electrocardiogram, noninvasive blood pressure, and temperature sensor, concentration of O_2 in the patient’s breathing system, pulse oximetry, and capnography. Mechanically ventilated patients should also have tidal volume and airway pressure monitoring. Urinary output is measured after bladder catheterization, which also serves to decompress the bladder prior to trocar placement.

Continuous capnography is useful in monitoring the effects of CO_2 absorption and the adverse cardiopulmonary effects of laparoscopy and anesthesia. Capnography measures exhaled CO_2 breath by breath allowing for determination of end-tidal CO_2 ($ETco_2$). Figure 3–1 shows a normal capnogram. Under normal physiologic conditions in healthy patients $ETco_2$ approximates $Paco_2$. A small gradient ($Paco_2$–$ETco_2$) of approximately 5 mm Hg exists because of dilution by dead space gases. $ETco_2$ is normally maintained between 35 and 40 mm Hg to ensure $Paco_2$ less than 45 mm Hg. Increased dead space ventilation in chronic obstructive pulmonary disease (COPD), acute respiratory distress syndrome (ARDS), and acute decreases in cardiac output make $ETco_2$ unreliable as an estimate of $Paco_2$ in these circumstances.[21,38] Arterial blood gas sampling remains the gold standard for evaluation of unanticipated trends or changes.[21] Arterial line placement for blood gas analysis allows close monitoring in prolonged procedures and in patients with severe cardiopulmonary diseases. Central venous pressure (CVP), pulmonary artery catheter (PAC) monitoring, and transesophageal echocardiography (TEE) are also indicated in patients with severe cardiopulmonary diseases and pheochromocytoma.[37,39] Portera and colleagues[39] prospectively evaluated 10 cardiac patients and found that the PAC identified 2 patients who developed postoperative congestive heart failure. Interpretation of CVP and PAC may be problematic, however, because IAP increases intrathoracic pressures, artificially elevating CVP and pulmonary artery occlusion pressures.[40] TEE is useful for the evaluation of left ventricle regional wall motion abnormalities, whereas continuous monitoring for the identification of gas embolism is not clinically practical. One recent study using TEE identified unexpected increased regurgitant valvular lesions in 15 of 16 healthy laparoscopic donor nephrectomy patients.[41]

Anesthetic Techniques

General anesthesia is most commonly chosen for transretroperitoneal or retroperitoneal laparoscopic procedures because of positioning requirements, need for optimal muscle relaxation, time to accomplish the procedure, patient discomfort associated with pneumoperitoneum, and the need to control ventilation in patients with cardiopulmonary diseases. A report from the Centers for Disease Control and Prevention revealed that almost a third of deaths with laparoscopic tubal sterilization occurred in patients who were breathing spontaneously and not intubated.[42] Regional and even local anesthesia, however, is increasingly performed in nonurologic laparoscopy.[43] Advantages of regional techniques (subarachnoid, epidural block, caudal block) include less postoperative pain and decreased emesis.[43] Chiu and associates[44] studied the cardiopulmonary effects of laparoscopic ligation of bilateral spermatic varices under epidural anesthesia and found decreased physiologic perturbations. Our group routinely uses adult caudal blocks for peritoneal procedures coupled with a laryngeal mask airway (LMA). Further evaluation is necessary before these can be recommended for patients with severe comorbid conditions. Disadvantages of regional techniques include the requirement for a T4 block to allow adequate analgesia, which is associated with dyspnea and sympathetic blockade–mediated hypotension. Shoulder pain, despite the high level of blockade, may still occur although at a reduced frequency.[45] Hyperbaric subarachnoid block may cause severe sympathetectomy and hypotension when used in the Trendelenburg position and should be avoided, whereas the risk with hypobaric solutions is reduced.[25,43]

General anesthesia and muscle relaxation afford the anesthetist and surgeon optimum conditions. Aspiration from positioning and peritoneal insufflation is reduced with cuffed endotracheal tube placement, although the LMA, which does not protect gastric content aspiration, has been used. A considerable amount of information and newer LMAs that

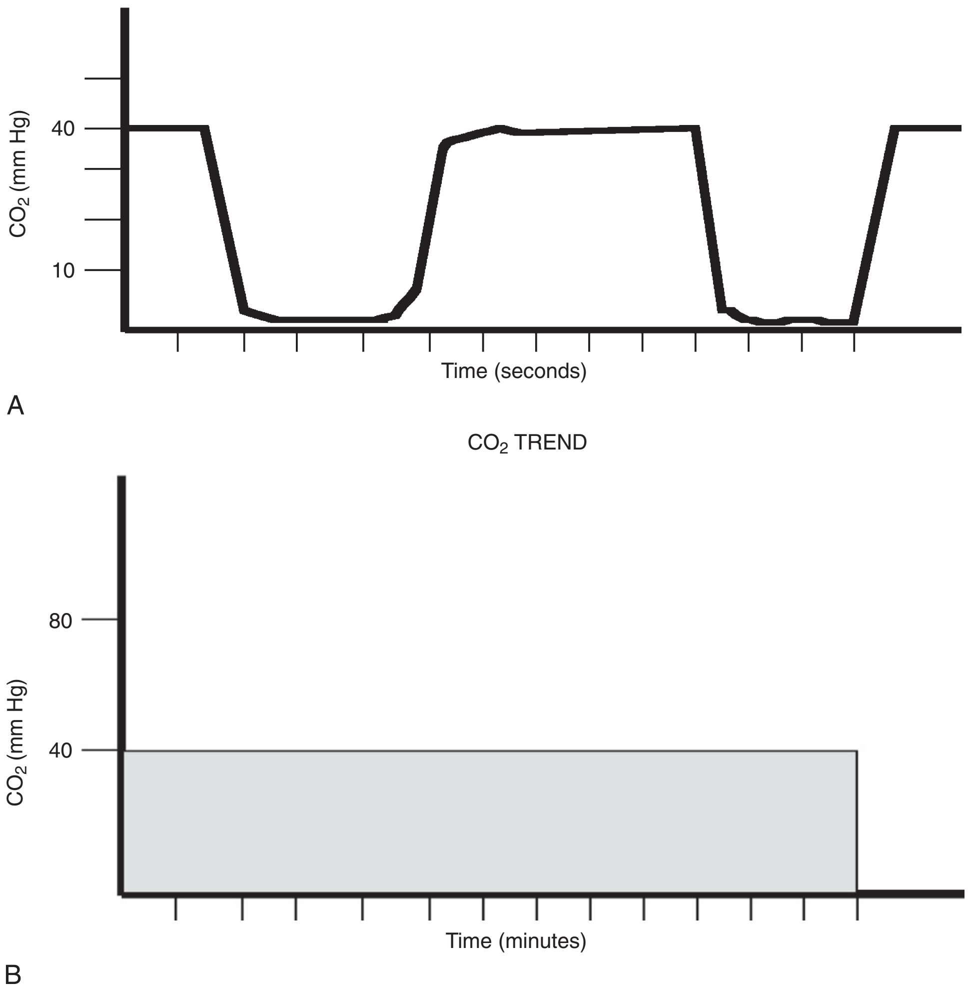

FIGURE 3–1. *A* and *B,* CO_2 reaches near 0 at the end of inspiration and beginning of expiration when dead space gas is exhaled. As expiration continues CO_2 rises rapidly toward the alveolar plateau, which lasts for the greater part of the trace. $ETco_2$ is measured immediately before inspiration begins the rapid downslope.

have a conduit for orogastric decompression (e.g., the ProSeal LMA) have facilitated the expanded use of LMAs for both laparoscopic procedures and procedures requiring positive pressure ventilation.[46–51] A survey regarding nearly 12,000 LMA insertions showed that close to 20% of insertions were for intra-abdominal, laparoscopic, or gynecologic procedures. All outcomes appeared comparable to those of standard endotracheal anesthesia.[51] Gastric perforation secondary to gastric insufflation during anesthesia induction and trocar placement can be minimized by orogastric/nasogastric decompression after anesthetic induction, which can be performed with the ProSeal LMA.[44,52] Mechanical ventilation using an LMA also allows adjustment of $ETco_2$ to less than 45 mm Hg.

There are no clear differences in anesthetic agents, although propofol has consistently been shown to decrease the incidence of postoperative nausea and vomiting (PONV).[53] N_2O has several properties that make it a useful anesthetic. Although not potent enough to be used alone, it decreases the minimum alveolar concentration (MAC) of the volatile anesthetic agents and its low solubility creates rapid induction and emergence. N_2O stimulates the sympathetic nervous system, which may exacerbate and confound the effects of peritoneal insufflation. Furthermore, N_2O is 35 times more soluble than nitrogen, which can produce bowel distention as well as worsen the effects of air embolism and pneumothorax. There is an ongoing clinical recognition of significant bowel distention during long laparoscopic procedures with the use of N_2O, but clinical studies do not support N_2O as the cause.[54,55] Newer volatile anesthetic agents such as desflurane and the risk of combustion obviate the need for N_2O because desflurane has a blood/gas partition coefficient less than that of N_2O, resulting in very rapid induction and emergence when used as the sole anesthetic. Interestingly, despite these concerns, almost all of the reports we reviewed regarding laparoscopic surgery included N_2O as part of the anesthetic regimen.

COMPLICATIONS

Intraoperative

Gastroesophageal Reflux/Aspiration Pneumonitis

Several diseases, such as diabetic gastropathy, hiatal hernia, renal failure, and others, as well as Trendelenburg position and

IAP from peritoneal insufflation theoretically predispose patients to an increased risk of aspiration during anesthesia. Controversy, however, exists regarding the effects of IAP.[56,57] One study found that increased IAP raised lower esophageal sphincter pressure to a greater degree than intragastric pressure, thereby actually decreasing the risk of regurgitation.[56] Additionally, studies evaluating the risk of aspiration using the LMA during gynecologic laparoscopy failed to document clinically significant aspiration or reflux.[51] Realistically, the risk for laparoscopic procedures is probably not different from that of other intra-abdominal surgical procedures. The aspiration risk is decreased when preoperative fasting guidelines are followed.[35] Clinically, intraoperative findings of significant aspiration include hypoxemia, elevated peak airway pressures from bronchospasm, and potentially hypotension (see Tables 3–5, 3–6, and 3–7 later).

Positioning-Related Nerve Injury

Care must be taken to avoid direct mechanical compression or excessive stretch on nerves. Although the ulnar nerve is the most frequently injured nerve associated with anesthesia, the pathophysiologic mechanism remains elusive.[58] The lithotomy position has been associated with compression and resultant common peroneal nerve injury.[59]

Positioning-Related Physiologic Effects

Position-related pulmonary and cardiovascular changes are common in lateral decubitus and head-up or -down positions. Head-down position increases CVP and CO. Usually, these changes are of minimal clinical significance, although patients with significant coronary artery disease may not tolerate increases in myocardial O_2 demand. As mentioned previously, pneumoperitoneum decreases FRC and pulmonary compliance resulting in $\dot{V}/\dot{Q}$ mismatch predisposing the patient to hypoxemia. Obese patients or those with coexisting respiratory disease exhibit marked responses that are magnified with increased head-down position. Pneumoperitoneum and the head-down position exacerbate raised ICP seen in patients with head trauma.[11,30] The head-up position and pneumoperitoneum usually result in a decrease in CO from a fall in preload[11,17–19] and an improvement in respiratory perturbations observed from pneumoperitoneum. Pneumatic compression stockings may attenuate impaired venous return by improving lower extremity venous blood flow.[60]

Hemorrhage From Vascular Injury

Fortunately, significant morbidity and mortality from vascular injury are rare, as is reexploration for postoperative hemorrhage. Although most injuries result from trochar or Veress needle insertion in other series, it appears that in urologic procedures most bleeding occurs during the dissection.[7] As increasingly complex laparoscopic surgeries are being performed requiring multiple ports, the risk of abdominal wall vessel injuries are becoming more common.[1] In some instances, particularly if an abdominal wall vessel or retroperitoneal vessel is injured, the bleeding can be concealed. A high degree of suspicion for hemorrhage must be maintained. In patients who have involved laparoscopic procedures or known bleeding diathesis, a type and screen should be performed.

Fluid Therapy Overload

Insensible fluid losses and interstitial space requirements are significantly less during laparoscopic procedures compared with during open laparotomy or retroperitoneal procedures, where fluid losses can exceed 8 to 12 mL/kg/hr. On the other hand, fluid loading has been associated with a decreased rate of nausea and vomiting,[61] a reduction in the magnitude of hemodynamic effects that are intensified by hypovolemia, and several cases of presumed volume overload.[15] The oliguric state secondary to vena cava and renal vein compression also creates the impression of decreased intravascular volume, which may lead to overhydration.[62,63] Clinical findings associated with fluid therapy volume overload include hypertension and hypoxemia from pulmonary edema. Cardiac patients may also develop myocardial ischemia and congestive heart failure manifested by arrhythmias, oliguria, and hypotension.

Insufflation/Pneumoperitoneum Related

Vagal Response

Insertion of the Veress needle or trocar, and more commonly peritoneal stretching from gas insufflation, can cause a profound vagal response manifested by hypotension, bradycardia, atrioventricular dissociation, and even asystole.[64–66] Correction is usually easily achieved by cessation of the surgical stimulation, release of the pneumoperitoneum, and the administration of atropine.[1,25]

Cardiac Dysrhythmias

The heart rate either does not change or increases slightly during insufflation and pneumoperitoneum. Bradydysrhythmias are common during insufflation.[1,11] Tachydysrhythmias occur less often but are common in the setting of hypercarbia, hypoxemia, acidosis, inadequate levels of anesthesia, and embolic events.

Hypercarbia

Hypercarbia is typically diagnosed intraoperatively when the $ETco_2$ rises above 45 mm Hg. Although it is well known that the insufflation of CO_2 results in the elevation of $Paco_2$ and its adverse physiologic consequences (see discussion on physiologic considerations unique to laparoscopy), there are several other diagnostic considerations.[67] Elevations of $Paco_2$ can arise from only four sources:

1. Increased metabolic production of CO_2
2. Increased absorbed CO_2
3. Decreased alveolar ventilation
4. Increased dead space ventilation

See Table 3–3 for the differential diagnosis of elevated $Paco_2$ during general anesthesia with mechanical ventilation. Figure 3–2 demonstrates the gradual increase in $ETco_2$ seen in these cases with the exception of increased dead space ventilation.

Any cause of increased $Paco_2$ from dead space ventilation will also cause an increased $Paco_2 - ETco_2$ gradient as a result of a concomitant decrease in $ETco_2$. The $ETco_2$ may dramatically decrease during pulmonary gas embolism, hypotension, and other situations (Fig. 3–3), despite significantly elevated $Paco_2$, making capnometry a valuable diagnostic tool and

TABLE 3–3. DIFFERENTIAL DIAGNOSIS OF ELEVATED Pa_{CO_2} DURING GENERAL ANESTHESIA WITH MECHANICAL VENTILATION

	Effect on ET_{CO_2}
Increased Metabolic Production	
Pyrexia	↑
Sepsis	↑
Malignant hyperthermia	↑
Shivering	↑
Thyroid storm	↑
Catecholamine release/pheochromocytoma	↑
Increased CO_2 Absorption	
CO_2-induced pneumoperitoneum	↑
CO_2-induced subcutaneous emphysema/ pneumomediastinum	↑
Capnothorax	↑
CO_2 rebreathing from failure of CO_2 absorber/breathing circuit valves	↑
Decreased Alveolar Ventilation	
Mechanical failure of endotracheal tube, breathing circuit, or ventilator	↑
Increased Dead Space Ventilation	
Pulmonary thromboembolism	↓
Pulmonary gas embolism	↓
Increased positive end-expiratory pressure (PEEP)	↓
High peak/plateau airway pressure	↓
Pulmonary disease	↓↑
Hypotension	↓

↑, increased; ↓, decreased.
Increased dead space ventilation causes $\dot{V}/\dot{Q}$ mismatch, which will increase the Pa_{CO_2}–ET_{CO_2} gradient. Increased PEEP and high airway pressures distend normal alveoli and compress alveolar capillaries increasing dead space ventilation. Pulmonary diseases such as bronchospasm, asthma, and chronic obstructive pulmonary disease may demonstrate elevations in ET_{CO_2} when Pa_{CO_2} is dramatically elevated.

monitor in laparoscopy. Arterial blood gas analysis, however, remains the gold standard for evaluation of Pa_{CO_2}.[21,38]

In mechanically ventilated healthy patients, the elevation of ET_{CO_2} and Pa_{CO_2} is easily remedied by increasing alveolar ventilation through increased respiratory rate or secondary tidal volumes.[25] In rare circumstances or in patients with severe cardiopulmonary disease, increased ventilation may be prohibited or ineffective necessitating conversion to an open procedure.[25] Wittgen and associates[21] reported 10 patients who underwent laparoscopic cholecystectomy with cardiac or pulmonary disease and recorded one case of conversion to an open procedure for severely elevated Pa_{CO_2} and acidosis. Table 3–4 lists the diagnostic and therapeutic maneuvers that should be performed when faced with severely increased ET_{CO_2}. Life-threatening complications should be ruled out or treated before a diagnosis of CO_2 absorption is made. A decreasing ET_{CO_2} particularly in the face of unchanged ventilation, hypotension, or O_2 desaturation should also prompt thorough diagnostic and therapeutic maneuvers to rule out pulmonary gas embolism, thromboembolism, or markedly decreased cardiac output.

CO_2 may be stored in tissues, remaining persistently elevated even after desufflation.[68] Patients should therefore be monitored before and after extubation to ensure adequate minute ventilation.

CO_2 and Gas Embolism

CO_2 embolism to the heart or pulmonary vessels has been observed in 69% of patients during laparoscopic cholecystectomy.[69] Fahy and associates[41] postulated, as have others,[1] that gas embolism would be higher in laparoscopic nephrectomy because of associated renal vein manipulation. Fahy and associates' study using continuous TEE documented only one episode

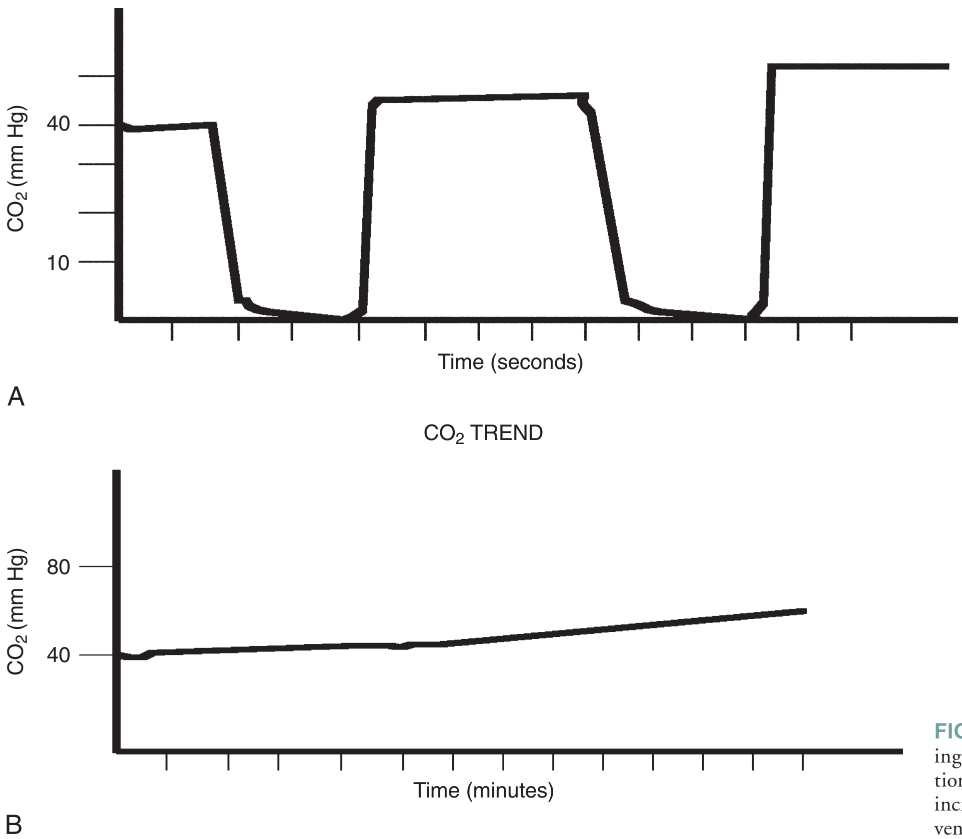

FIGURE 3–2. *A* and *B*, Capnometry demonstrating the slow increase in CO_2 seen with CO_2 absorption and other causes of elevated Pa_{CO_2} such as increased CO_2 production or decreased alveolar ventilation.

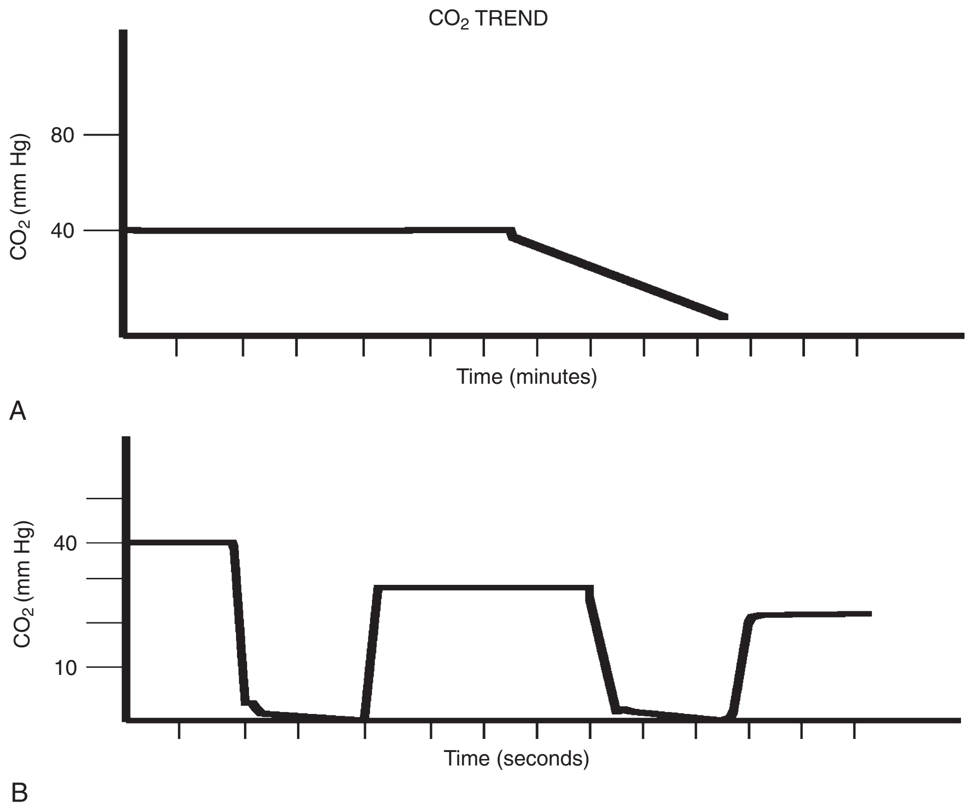

FIGURE 3–3. *A* and *B*, Capnometry demonstrating a decrease in ETCO_2 seen in cases of increasing dead space ventilation such as pulmonary embolism or decreased cardiac output.

TABLE 3–4. EVALUATION AND MANAGEMENT OF ELEVATED ETCO_2 DURING MECHANICAL VENTILATION

Evaluation	Therapy
1. Ensure adequate oxygenation	1. Place on 100% FIO_2
2. Auscultate for bilateral breath sounds Rule out mechanical malfunction capnothorax, endobronchial intubation, wheezing	2. Use alternative breathing circuit, decompress chest, reposition ETT. Treat bronchospasm
3. Check inspired CO_2 level; >2 mm Hg indicates rebreathing	3. Change CO_2 absorber, inspiratory/expiratory valves; increase fresh gas flow
4. Associated with CO_2 insufflation	4. Increase alveolar ventilation: Tidal volumes 10–12 mL/kg or PAWP <35 Respiratory rate maximum 18–24 Avoid PEEP if O_2 saturation is adequate Ensure adequate intravascular volume
5. Check arterial blood gas Rule out causes of increased CO_2 production: pyrexia, malignant hyperthermia, etc	5. As indicated; cooling, dantrolene
6. Palpate skin to rule out subcutaneous CO_2 emphysema	6. Create "blow holes" to allow CO_2 escape
7. Other etiologies excluded, PaCO_2 >55 mm Hg with acidosis	7. Limit intra-abdominal pressure, change patient position
8. Associated with hypotension, hypoxemia, or severe elevations in PAWP	8. Convert to an open procedure

ETT, endotracheal tube, FIO_2, fraction inspired concentration of O_2, PAWP, peak airway pressure, PEEP, positive end-expiratory pressure.
This is a suggested algorithm that can be followed to evaluate and treat severe increases in ETCO_2. The therapies are not intended to be mutually exclusive. Endobronchial intubation would be an uncommon cause of elevated CO_2 but can be seen in patients with cardiopulmonary diseases.

of gas embolism out of 16 cases (6%), which did not result in any hemodynamic instability.[41] The exact incidence of gas embolism is not known but it remains rare.[69–71] Unfortunately, gas embolism can be catastrophic, resulting in severe cardiovascular collapse or death.[69–71]

Initial insufflation of pressurized gas is the most common period to observe gas embolism during laparoscopy. Vascular injury or direct placement of the Veress needle/trocar into a vein or vascularized parenchymal organ, such as the liver, can cause significant embolism if not detected early.[1,70,71] The high solubility of CO_2 means that significantly larger volumes of gas (>25 mL/kg, 1200 mL, >1 L/min) are necessary compared to air (>3–5 mL/kg, 240 mL) or He, to cause clinically significant embolism.[1,72] If an embolism does occur, its solubility results in rapid resolution.[1,71] The risk of embolism is decreased by mechanical ventilation with positive pressure, adequate

hydration, limiting CO_2 insufflation pressure and volume to less than 30 mm Hg and 3 L.[69,71] Monitoring with precordial Doppler and TEE has been advocated for procedures with significant risk such as posterior fossa craniotomy in the sitting position but is not practical on a routine basis for laparoscopy.

Clinical signs of embolism include sudden hypotension, hypoxemia, tachycardia, and arrhythmias. $ETco_2$ may initially increase, but if the embolism does not resolve quickly, it will fall dramatically (see Fig. 3–3) from cardiovascular collapse and decreased pulmonary perfusion. The classic finding of a "mill wheel murmur" is a late finding and rarely appreciated in air embolism but has been appreciated in CO_2 embolism.[71]

Therapy includes immediate cessation of pressurized gas, discontinuation of N_2O, administration of 100% O_2, Valsalva maneuver to prevent further gas entry into the heart and lungs, elevation of CVP by administration of intravenous fluids, and hemodynamic and cardiac support as needed. N_2O has been traditionally thought not to result in an increase in the size of CO_2 bubbles because of similar solubilities but Junghans and colleagues[73] demonstrated in a recent study that the addition of N_2O did in fact worsen hemodynamics and cardiac function. The optimum patient position to limit and treat gas embolism is currently controversial. Most surgeons recommend the position described by Durant over 50 years ago—Trendelenburg (head down), left lateral decubitus to trap air in the right ventricle (see Chapter 1)—although recent animal studies do not support this.[74–76] Geissler and associates[76] studied venous air embolism with TEE, finding that body position did not benefit hemodynamic performance and that cardiac decompensation was not from air lock of the right ventricular outflow tract but rather the effect of right ventricular ischemia. Trendelenburg position may also exacerbate the resultant cerebral edema, pulmonary mechanics, and hemodynamics seen with cephalad movement of the diaphragm.[71,76] Practically speaking, the supine position facilitates therapeutic intervention, although further studies are need to establish the optimum position for resuscitation. Clinically, placement of a central line, if not already in situ, with aspiration of air may take several minutes, and hyperbaric therapy, while controversial, also may not be readily available.[77,78] If cardiac arrest occurs and embolism does not correct quickly, thoracotomy with direct aspiration, internal cardiac massage, and cardiac bypass may be lifesaving.

Emphysema (Subcutaneous/Preperitoneal)

Subcutaneous CO_2 emphysema may be appreciated by the surgical team or anesthetist as crepitance of the skin on the abdomen, thorax, neck, or face. Alternatively, elevations of the $ETco_2$ may precipitate evaluation of the hypercarbia (see Table 3–4). Although it can occur during removal of the insufflating trocar, it most commonly manifests during Veress needle/trocar insertion.[75,79,80] The Veress needle/trocar may be improperly placed or CO_2 may inadvertently leak around the trocar.[1,75] The surgical team should be well versed in recognition and malfunctions during insufflation. Preperitoneal needle placement can result in penile and scrotal subcutaneous emphysema. Subcutaneous emphysema during laparoscopy may also result from pulmonary barotrauma associated with high tidal volumes or increased airway pressures. Clinically, hypercarbia from the subcutaneous absorption of CO_2 may become problematic, necessitating increased minute ventilation, although more frequently it looks worse than it is. No significant hemodynamic sequelae should result, although if accompanied by hypotension, increased airway pressure, or hypoxemia, pneumothorax should be ruled out. An abrupt increase in $ETco_2$ is the first sign of subcutaneous emphysema and of pneumothorax.[67] Desaturation and increased airway pressure occur with pneumothorax but not with subcutaneous emphysema alone. Subcutaneous emphysema rapidly resolves and no therapy is typically needed, but subcutaneous intravenous catheters can be placed or simple skin incision "blow holes" may be created to allow the CO_2 to escape into the atmosphere. Figure 3–4 shows a chest radiograph of a patient with massive subcutaneous gas.

Pneumothorax, Pneumomediastinum, and Pneumopericardium

Subcutaneous CO_2 emphysema may occur as an isolated phenomenon or, more ominously, may be the harbinger of pneumothorax (PTX), pneumomediastinum (PMD), or pneumopericardium (PPM).[67,79,81–83] For example, the patient in Figure 3–4 presented initially with massive subcutaneous emphysema but developed hypotension and hypoxemia suggestive of PTX, resulting in bilateral chest tube thoracostomy and subsequent hemodynamic improvement. Similarly, PTX, PMD, or PPM may occur without evidence of each other or subcutaneous emphysema. Isolated PMD and PPM do not typically have significant clinical effects and are found incidentally on postoperative chest radiograph or when patients complain of substernal chest pains.[84] Clinical signs include elevated $ETco_2$, hypotension, hypoxemia, or elevated peak airway pressures,

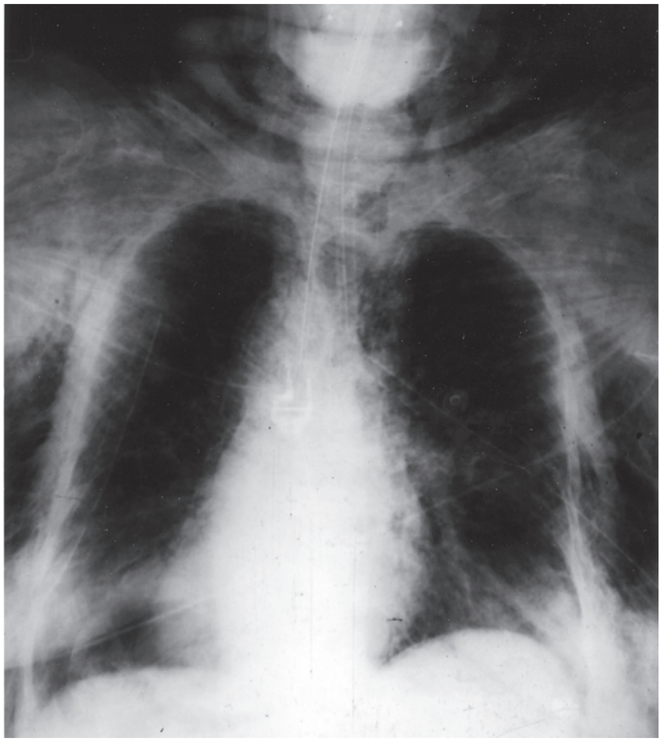

FIGURE 3–4. This patient developed massive subcutaneous emphysema, which was followed by hypotension and hypoxemia. Bilateral chest tubes were placed with gas release and immediate improvement in hemodynamics and oxygenation.

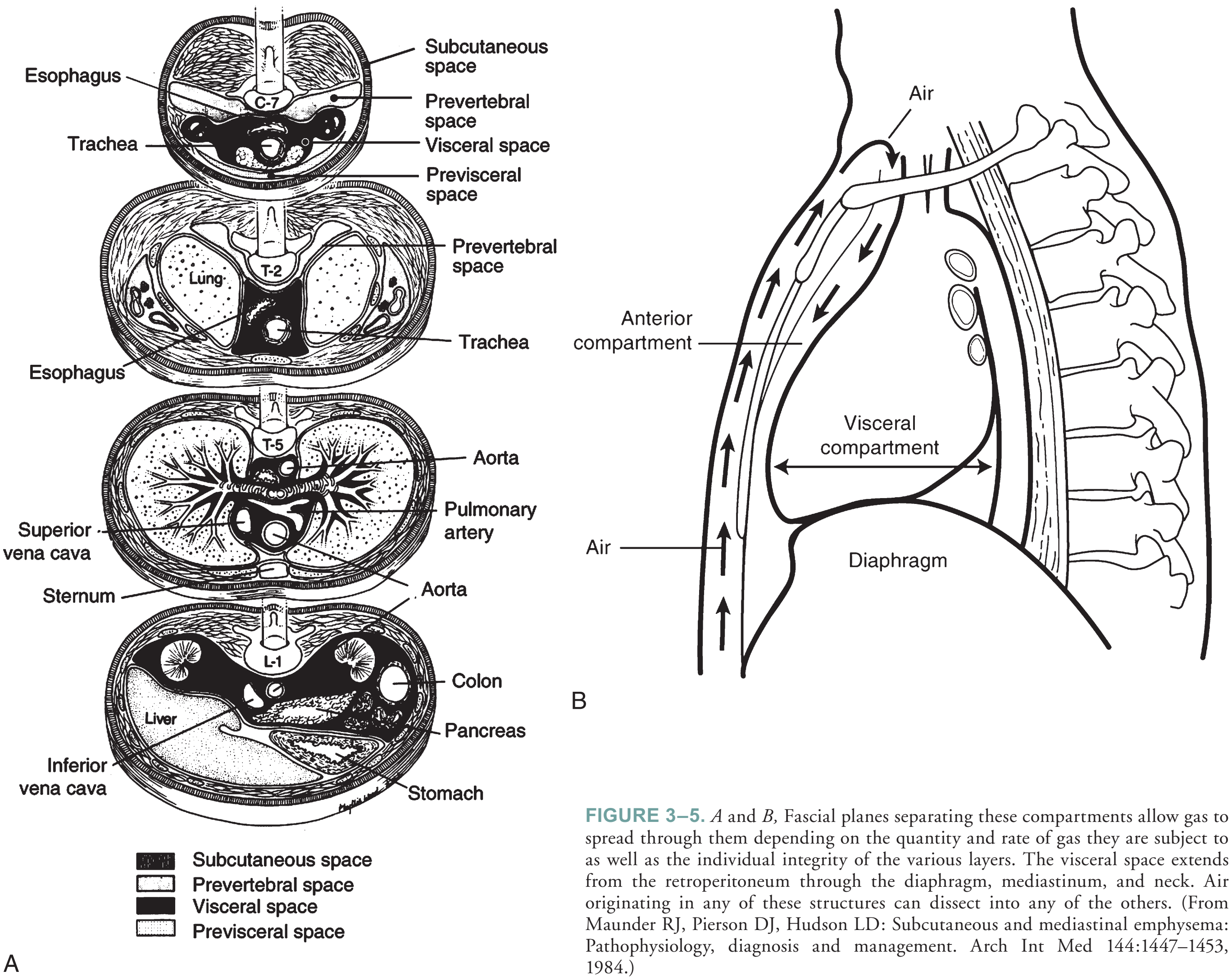

FIGURE 3–5. *A* and *B,* Fascial planes separating these compartments allow gas to spread through them depending on the quantity and rate of gas they are subject to as well as the individual integrity of the various layers. The visceral space extends from the retroperitoneum through the diaphragm, mediastinum, and neck. Air originating in any of these structures can dissect into any of the others. (From Maunder RJ, Pierson DJ, Hudson LD: Subcutaneous and mediastinal emphysema: Pathophysiology, diagnosis and management. Arch Int Med 144:1447–1453, 1984.)

which should prompt the evaluation for potentially catastrophic complications such as a tension PTX. Decreased unilateral or bilateral breath sounds, neck vein distention, and tracheal deviation are not very sensitive intraoperatively, so high clinical suspicion is needed.

Similar to subcutaneous emphysema, PTX, PMD, and PPM may be the result of pulmonary volume trauma or barotrauma from elevated pulmonary airway pressures. Patients typically have underlying pulmonary disease such as bullous emphysema, bleb disease, pulmonary cyst, or another underlying predisposing condition.

Insufflation of CO_2 causes PTX, PMD, and PPM via several mechanisms. Pneumothorax (capnothorax) results from either congenital defects in the diaphragm, diaphragm injury, dissection through fascial retroperitoneal planes, or inadvertent trocar placement into the pleural space.[15,85] Figure 3–5 demonstrates the continuity of the retroperitoneal spaces with the mediastinum, thorax, neck, and chest wall, which is one of the anatomic reasons that explains how CO_2 can dissect through tissue planes to cause PTX, PMD, and PPM. If discovered during positive pressure ventilation or with associated hemodynamic and respiratory compromise, 100% O_2, discontinuation of N_2O, intravenous fluid therapy, vasopressor support, hand ventilation, and immediate desufflation should relieve the capnothorax. Many surgeons note that a capnothorax will resolve within 30 minutes and no treatment is necessary; however, we believe that if immediate improvement is not seen, needle decompression or chest tube thoracostomy is indicated because pulmonary volume or barotrauma cannot be easily differentiated. Cessation of insufflation and evaluation prior to continuance is mandatory, and conversion to an open procedure may be required. Postoperative discovery is not unusual and, because of the solubility of CO_2, typically results in rapid resolution of symptomatic patients with PTX of less than 20%. These patients can be managed with observation.[15,85]

Hypotension

Hypotension is defined as a fall in arterial blood pressure of more than 20% below baseline, an absolute value of systolic pressure below 90 mm Hg, or an MAP below 60 mm Hg. Hemodynamic perturbations are common during laparoscopy, but the incidence of serious cardiovascular complications is low.[1,11] Hypotension is most frequently caused by a decrease in venous return during development of pneumoperitoneum.[17,86] However, a thorough differential diagnosis of hypotension in

TABLE 3–5. DIFFERENTIAL DIAGNOSIS OF HYPOTENSION IN THE PATIENT UNDERGOING LAPAROSCOPIC SURGERY

Rate/Rhythm
Bradysrhythmias: CO_2 insufflation, traction on pelvic structures
Tachydysrhythmias: sinus tachycardia and ventricular dysrhythmias

↓ Preload
Hypovolemia
Caval compression
Vasodilation
Excessive pneumoperitoneum
Abrupt change in patient position
Tension pneumothorax
Pericardial tamponade

↓ Contractility
Hypoxemia
Myocardial ischemia
Drug-induced myocardial depression
Right ventricular failure from embolic event
Acute valve dysfunction
Severe acidosis
Abrupt increase in SVR

↓ Afterload (SVR)
Drugs
Distributive mechanisms: sepsis, anaphylaxis, neurogenic, addisonian crisis, transfusion reaction
Histamine release

SVR, systemic vascular resistance.

BOX 3–1. Differential Diagnosis of Intraoperative Hypertension in the Patient Undergoing Laparoscopic Surgery

- Hypoxemia
- Hypercarbia
- Pneumoperitoneum
- Light anesthesia
- Preexisting hypertension
  - Primary
  - Renovascular
- Volume overload
- Drugs
- Elevated intracranial pressure
- Autonomic hyperreflexia
- Malignant hyperthermia
- Endocrine
  - Pheochromocytoma, carcinoid, glomus tumors, thyrotoxicosis

Courtesy of Steven G. Venticinque, MD.

the anesthetized patient undergoing laparoscopic surgery should be considered (Table 3–5) with treatment directed by the cause. Most frequently, it involves release of the pneumoperitoneum. Vasopressor agents are commonly used to temporize perfusion to the heart and brain, although they are detrimental in the setting of hypovolemic or hemorrhagic shock. Atropine is indicated for bradydysrhythmias thought to be the cause of the hypotension. While less common, hypertension may also occur; hypertension also warrants a thorough differential (Box 3–1).

TABLE 3–6. DIFFERENTIAL DIAGNOSIS OF INTRAOPERATIVE INCREASED PEAK AIRWAY PRESSURE IN THE PATIENT UNDERGOING LAPAROSCOPIC SURGERY

Anesthesia Circuit Factors
Kink
Secretions
One-way valve malfunction

Endotracheal Tube Factors
Endobronchial intubation
Secretions
Kink or patient biting on endotracheal tube

Patient Factors
Pneumoperitoneum
Bronchospasm
Mucus plug
Pneumothorax, hemothorax
Pulmonary edema
ARDS, pneumonia, aspiration
Poor baseline pulmonary compliance
  Restrictive lung disease
  Obesity
  Kyphoscoliosis

ARDS, acute respiratory distress syndrome.

Elevated Peak Airway Pressures

Functional residual capacity (FRC) and lung compliance decrease with pneumoperitoneum.[11] Several studies have documented increased peak airway pressures during pneumoperitoneum.[23,27] The peak airway pressures increase approximately 50% above baseline values.[11] Interestingly, patients with documented cardiorespiratory disease did not appear to have significant elevation in peak airway pressures beyond patients with normal cardiopulmonary status.[21] Position changes such head-up or head-down do not appreciably alter peak airway pressures.[27] Other airway misadventures must be in the differential diagnosis of increased peak airway pressure (Table 3–6). Patients with significant pulmonary disease may manifest marked elevations of $Paco_2$ as a result of the ventilator-limiting airway pressures and in some circumstances may make maintaining a pneumoperitoneum difficult. Despite this, patients with significant pulmonary disease should not be dismissed as potential candidates for laparoscopic surgery and they may in fact benefit postoperatively. Fortunately, once the pneumoperitoneum is released the inspiratory airway pressures return to baseline.

Hypoxemia

With the institution of the pneumoperitoneum there is a drop in Pao_2. This decrease in the Pao_2 rarely results in hypoxemia in ASA (American Society of Anesthesiology physical classification) I/II patients.[11] Some reports demonstrate an increased Pao_2 when local anesthesia was used.[87] When hypoxemia occurs, many potential etiologies should be considered (Table 3–7). Baseline decreases in Pao_2 may result in more significant decreases on insufflation. Patients who require home O_2 are at high risk for hypoxemia and may require periodic release of the pneumoperitoneum. Smokers may also be more prone to hypoxemia.[88] In addition, endobronchial intubation is common during pneumoperitoneum secondary to the cephalad movement of the diaphragm.[89] Peak end-expiratory pressure may be

TABLE 3–7. DIFFERENTIAL DIAGNOSIS OF HYPOXEMIA IN THE PATIENT UNDERGOING LAPAROSCOPIC SURGERY

Hypoventilation
Esophageal intubation
Main stem intubation
Failure to ventilate
Airway obstruction
Pneumoperitoneum
$\dot{V}/\dot{Q}$ Mismatch
Main stem intubation
Atelectasis
Pulmonary edema
Bronchospasm
Aspiration
ARDS
Pneumothorax
Embolic phenomena
Shunt
Intrapulmonary
Intracardiac
Diminished $S\bar{v}O_2$
Shock
Decreased functional residual capacity compared with closing capacity

ARDS, acute respiratory distress syndrome.

useful in increasing mean airway pressure, which may improve oxygenation. The immediate treatment of hypoxemia involves increasing the delivered O_2 to the patient. Some surgeons advocate an FIO_2 of greater than 50% to provide an added margin of safety during insufflation.

Oliguria

Decreased urine output is a common complication of pneumoperitoneum and pneumoretroperitoneum.[90] The mechanism for the decreased urine output cannot simply be explained by decreased venous return with subsequent decreased cardiac output.[91,92] If this were the only factor, then expansion of the blood volume should improve urine output. Animal studies have demonstrated that extrarenal pressures as little as 10 mm Hg impair renal blood flow and urine production.[92,93] Neurohormonal factors play a role in the decreased urine output observed clinically. Pneumoperitoneum increases plasma renin and ADH levels.[90] One study found warm insufflating CO_2 to be associated with greater urine output.[94]

Anesthetic drugs also decrease renal blood flow, GFR, and urine output.[95] The decrease in urine output due to anesthetic-related effects can be attenuated by perioperative hydration.[91,92] Once the pneumoperitoneum or pneumoretroperitoneum is deflated, an increase in urine output should follow. If prompt improvement of urine output does not occur, a thorough search for other etiologies should be conducted (Table 3–8).

TABLE 3–8. DIFFERENTIAL DIAGNOSIS OF OLIGURIA IN THE PATIENT UNDERGOING LAPAROSCOPIC SURGERY

Prerenal	**Postrenal**
Hypovolemia	Obstruction
Decreased cardiac output	Bladder catheter
Hypotension	Ureteral
Intrinsic	
Acute tubular necrosis	
Increased ADH	
Glomerulonephritis	

ADH, antidiuretic hormone.

POSTOPERATIVE MANAGEMENT

Nausea and Emesis

PONV is one of the most frequent complaints following laparoscopic procedures. Risks for PONV include laparoscopic surgery, female gender, history of PONV or motion sickness, postoperative opioid use, and nonsmoker.[96] Increased number of risk factors correlates with increased incidence of PONV.[97] While PONV is considered a minor complaint, it can be quite distressing to the patient and leads to increased length of stay in the ambulatory surgical center and decreased patient satisfaction.[98] Gan provided useful guidelines for prophylactic antiemetic therapy based on multimodal therapy[96] (Fig. 3–6). Other factors that may decrease PONV are stomach drainage[99] and possibly the avoidance of N_2O.[57] Nonopioid analgesics not only may be beneficial in reducing the pain after laparoscopic surgery but also may decrease PONV by minimizing postoperative opioids.

Postoperative Pain

Postoperative pain from laparoscopy is significantly less than that from laparotomy, although patients can have significant discomfort following laparoscopic procedures. Shoulder and neck pain is reported by up to 63% of patients following laparoscopic procedures.[100–102] Pain after laparoscopic surgery occurs at multiple locations and typically has a bimodal distribution. Visceral pan predominates immediately after the surgery and subsides quickly while shoulder pain can increase and not peak for up to 3 days.[103] Pain out of proportion to the procedure should prompt an investigation for possible surgical causes (e.g., hemorrhage, bladder perforation, bowel injury, nerve injury).

There are a variety of techniques used to minimize discomfort after laparoscopic procedures (Table 3–9). Many of these techniques have conflicting data regarding their efficacy. In addition, many of these techniques help with pain in the immediate postoperative period but have little effect within 24 hours. That being said, many of these techniques are safe and should be considered. The most promising technique for reduction of postoperative pain appears to be multimodal therapy whereby opioids, nonsteroidal anti-inflammatory drugs, modification of the gas, and local anesthetics are used.

There are a large variety of pharmacologic measures that can reduce postoperative pain. Opioids are effective in alleviating postsurgical discomfort. However, these drugs, in larger doses, have side effects, making their use less desirable (e.g., PONV, sedation, respiratory depression). Other analgesics that can be considered include tramadol and acetaminophen. Nonsteroidal anti-inflammatory drugs have a role for postoperative pain, although it is probably not as great as previously thought.[100,101] More novel pharmacologic measures have been investigated; one of these is low-dose ketamine. Ketamine as an analgesic adjunct has been shown to reduce postoperative pain and opioid requirements and the incidence of residual pain until the sixth

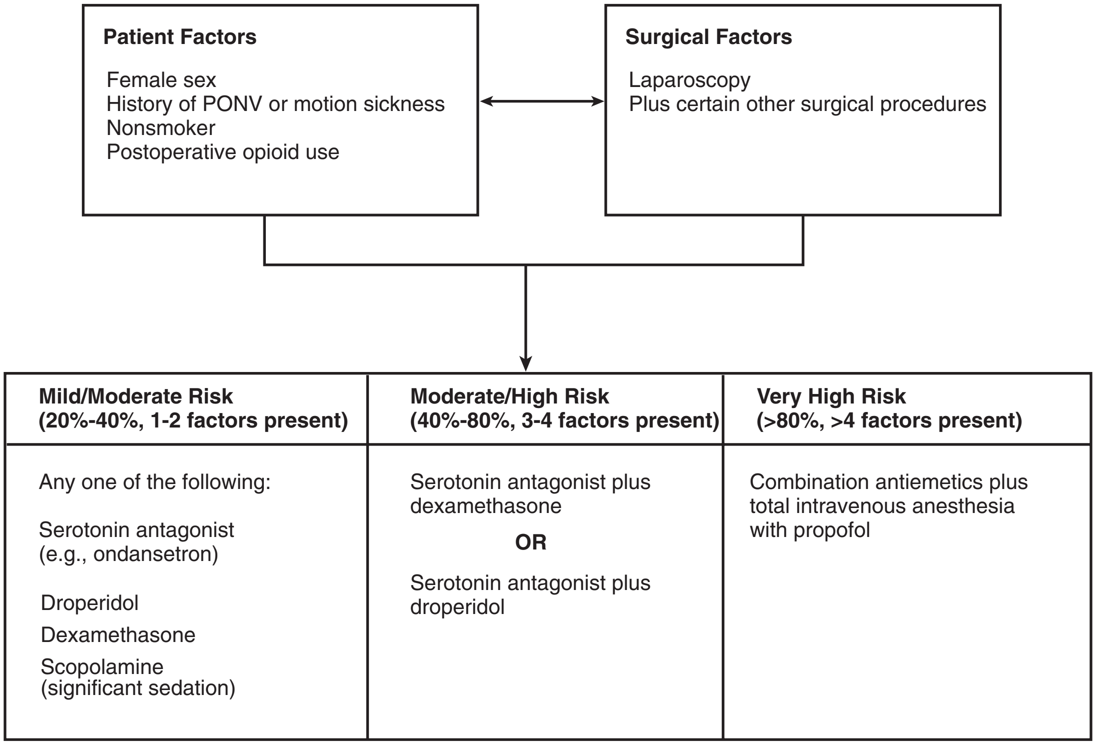

FIGURE 3–6. Treatment strategies for the prophylaxis of postoperative nausea and vomiting. (Adapted from Gan TJ: Postoperative nausea and vomiting—Can it be eliminated? JAMA 287:1233–1236, 2002.)

TABLE 3–9. ANALGESIC STRATEGIES FOR PATIENT UNDERGOING LAPAROSCOPIC SURGERY

Pharmacologic
Opioids
NSAIDs
Acetaminophen
Acetazolamide
Ketamine
Wound Bed Manipulation
Subcutaneous local anesthetic
Intra-abdominal local anesthetic
Intra-abdominal saline
Manipulation of Insufflation Gas
Heating
Humidification
Aspiration of gas
Low-pressure insufflation
Low-flow insufflation

month.[104] Use of ketamine with major renal surgery also showed a decrease in postoperative analgesic requirements.[105] Even acetazolamide has been given with modest success in reduction of referred pain in the immediate postoperative period.[106]

Local anesthetics have been looked at to relieve postoperative pain, again with varying success. Local anesthetics have been infiltrated both at and in the port sites. These interventions appear to provide brief relief[101]; interestingly, even the instillation of a relatively large volume of normal saline confers some benefit.[107] In addition to agents, there are interventions that can be done involving the insufflating gas; removal of the gas has shown minimal effect, whereas heating of the insufflating gas has the ability to produce a prolonged reduction in pain.[102] Low-pressure insufflation also appears to offer similar advantages as heated gases.[101,108]

Pulmonary Impairment

Postoperative pulmonary complications (PPCs) are an important area of morbidity and mortality in clinical medicine. PPCs comprise a group of events such as pneumonia, respiratory failure, bronchospasm, atelectasis, and hypoxemia.[109] Risk factors for PPCs include surgery lasting longer than 3 hours, general anesthesia, upper abdominal surgery or thoracic surgery, and intraoperative use of pancuronium.[110] Potential patient-related risk factors include smoking, ASA class greater than II, age older than 70 years, obesity, obstructive sleep apnea, and COPD.[110] The risk of PPCs is lower in patients who undergo laparoscopic cholecystectomy than those undergoing open cholecystectomy.[110] There are a multitude of studies showing improved postoperative pulmonary function when comparing laparoscopy with laparotomy.[25] Strategies to improve postoperative pulmonary function have been outlined elsewhere.[109,110]

SUMMARY

Minimally invasive urologic surgery is increasingly common. Postoperative benefits include less pain, shorter hospital stay, and better postoperative pulmonary function. As more procedures are performed laparoscopically, the anesthesiologist and urologist need to understand the unique physiologic events that occur as a result of laparoscopy. For the healthy patient undergoing laparoscopy, the cardiorespiratory events are usually little more than minor intraoperative issues. However, for the patient with cardiac or pulmonary compromise, the physiologic

perturbation can be more severe and requires more preoperative planning.

Tips and Tricks

- It is important to avoid and recognize the adverse physiologic affects associated with laparoscopic surgery.
- The capnograph is a useful tool to diagnose and differentiate causes of adverse affects associated with CO_2 insufflation.
- The surgery team, including operative nurses and anesthesia providers, should routinely discuss and rehearse the management and therapy of severe adverse affects related to positioning, increased intra-abdominal pressure, and CO_2 insufflation.
- Multimodality therapy for the prophylaxis of postoperative nausea and vomiting as well as postoperative pain can decrease patient discomfort and improve patient satisfaction with minimally invasive surgery.

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CHAPTER 4

Closure Techniques and Exiting the Abdomen

Benjamin R. Lee

One of the most challenging aspects of laparoscopic surgery is to maintain discipline once the operative portion is complete. Continued concentration is necessary to avoid complications. Several techniques exist for closure of fascia while the pneumoperitoneum is still present. Using direct visualization, one can complete closure and confirm that the approximating suture did not catch an underlying structure. After desufflation and closure of the fascia, the trocar sites must be irrigated and superficial bleeding controlled. Radially expanding trocars allow for the possibility of not having to perform fascial closure. A subcuticular closure of the skin with 4-0 Vicryl is performed for all trocar sites, and then Steristrips are applied to the skin.

HAND CLOSURE

Closing fascia through small skin incisions can be challenging. It is important to directly visualize the fascia to ensure proper closure. Only the anterior fascia must be reapproximated to obtain a secure incision because this decreases the potential risk of injury to underlying bowel. The fascial layer can be hand closed with a 2-0 Vicryl suture, which is available on several different needles that are suited for laparoscopic ports. The UR-6 tapered needle allows easy rotation to catch the fascia. If possible, place a Kocher clamp on the fascia to assist with exposure. Use two Army-Navy retractors to retract the skin and adipose tissue to assist with exposure of the fascia. A single figure-of-eight suture placed full thickness through the fascia is usually sufficient to close the defect. Take care to confirm that no bowel segments are trapped within the stitch.[1]

Two needles have been designed specifically for closure of trocar ports. The TN needle (Ethicon Endo-Surgery, Cincinnati, OH) is attached to a single-armed, 27-inch polydioxanone suture (PDS) II or coated Vicryl suture in the 2-0 or 0 size. The TN needle is positioned at a right angle with the fascial edge and rolled up through the fascia. The J needles (Ethicon Endo-Surgery) are double-armed on an 18-cm strand of PDS II or coated Vicryl suture in the 2-0 or 0 size. Each J needle is inserted parallel with the fascial edge and rotated 90 degrees through the edges of the fascia (Fig. 4–1).

CARTER-THOMASON DEVICE

The Carter-Thomason needlepoint fascial closure device (Inlet Medical, Eden Prairie, MN) is a single-action jaw at the end of a sharp, needle-pointed grasper (Fig. 4–2). This construction allows three so-called degrees of freedom:

1. Translational movement in and out of the abdomen
2. Rotational movement
3. An end-effector jaw that allows it to grasp the suture[2]

The jaw is open in the activated state to allow a looped, double-stranded 2-0 Vicryl suture or a No. 1 Vicryl with its longer length of suture to be secured within the jaws of the device. By retracting the spring-loaded, handheld grip, one can open the jaw and grasp the suture.

The first pass of the Carter-Thomason device starts on the side of the incision away from the camera to optimize visualization and location of the suture during the second pass of the device. Under direct visualization, pierce the needle tip holding the suture lateral to the incision into the abdomen and advance it away from the camera. Retract the spring-action handle and drop the suture free. With the suture disengaged, close the jaws under direct vision and withdraw the device, leaving one loop of the suture passed through one fascial edge.

Then insert the Carter-Thomason device on the opposite, proximal side of the incision, again under direct visualization. Open the single-action jaw, grasp the loop of suture, and pull the suture up through the incision. Place a grasper through if needed to pass the suture loop to the jaws of the Carter-Thomason device. Then tie the ends of the suture, and examine the peritoneal view of the fascial closure for bleeding and trapped viscera. After placing the fascial suture, but before tying it, reinsert a trocar to allow camera placement for direct visualization of closure of the other sites. This instrument is my preference for fascial closure because it allows ease of suture placement under direct visualization.

A conical metal introducer comes with the device; however, the placement of the suture can also be digitally guided. The index finger of the nondominant hand occludes the abdominal wall defect to prevent loss of pneumoperitoneum. This finger also palpates the edge of the fascia to guide proper needle placement.

ENDOCLOSE DEVICE

The EndoClose (U.S. Surgical, Norwalk, CT) is a disposable spring-loaded blunt stylet with a hook that retracts into a sheath as the 14-gauge needle is pushed through the abdominal wall.[3] This device has two so-called degrees of freedom: translational (in and out) and rotational. It is used much like the Carter-Thomason device.

Load the EndoClose by depressing the top button then placing a loop of suture into the notched portion of the internal

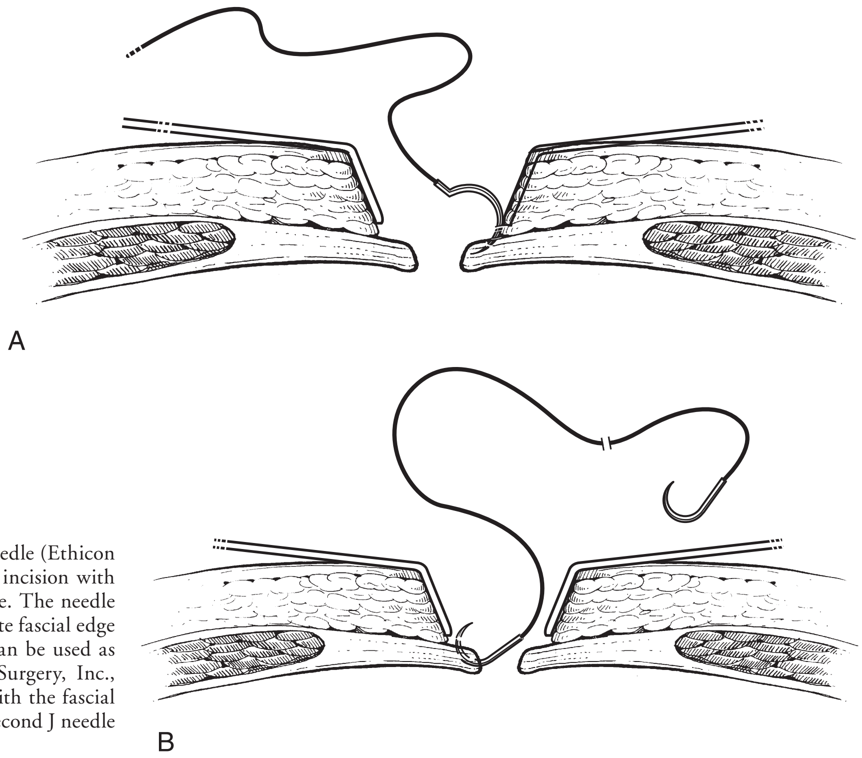

FIGURE 4–1. Hand closure. *A,* The single-armed TN needle (Ethicon Endo-Surgery, Inc., Cincinnati, OH) is inserted into the incision with the needle positioned at a right angle with the fascial edge. The needle is angled upward and rolled through the fascia. The opposite fascial edge is sutured in a similar manner. A figure-of-eight suture can be used as needed. *B,* The double-armed J needle (Ethicon Endo-Surgery, Inc., Cincinnati, OH) is inserted into the trocar site parallel with the fascial edge and is then rotated 90 degrees through the fascia. A second J needle is passed through the opposite fascial edge.

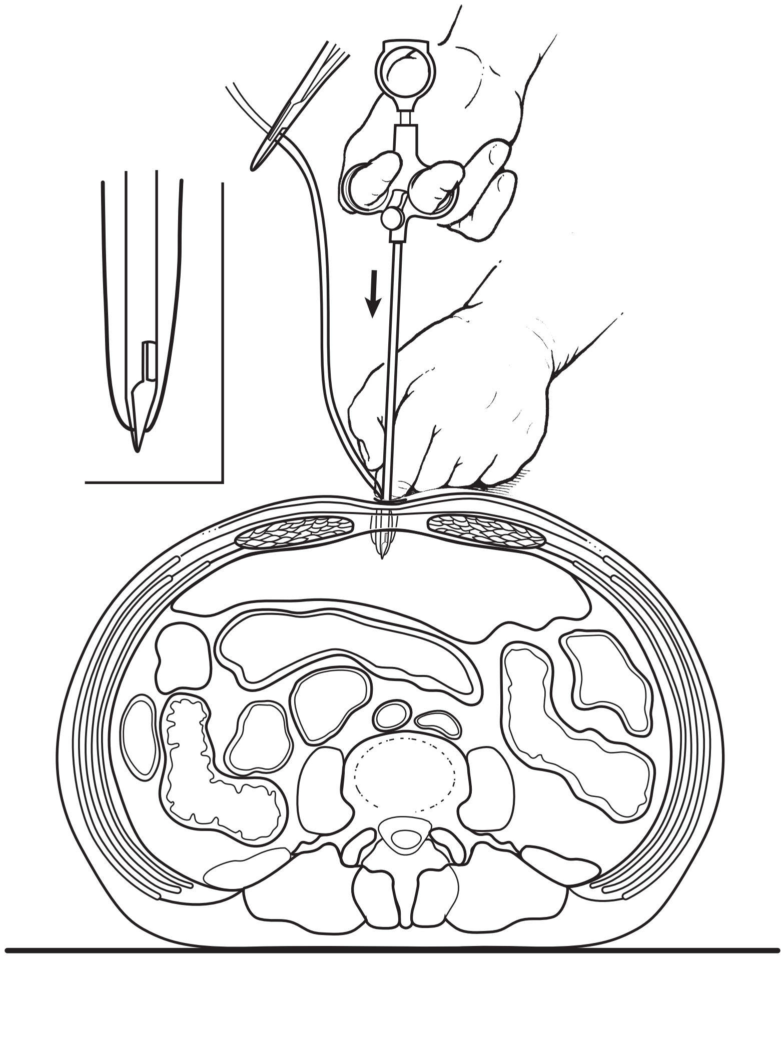

FIGURE 4–2. Carter-Thomason fascial closure device (Inlet Medical, Eden Prairie, MN). The Carter-Thomason device has three degrees of freedom (see text). The single-action jaw at the tip of the needle-pointed grasper increases the dexterity of the instrument. After the trocar is removed, the surgeon's finger is used to maintain the pneumoperitoneum. The device with a loaded 2-0 Vicryl suture is passed through the fascia, under direct vision, on the side farther from the camera, and the suture is released. The device is then reinserted on the opposite side of the incision, and the jaws are opened to grasp the suture. With the jaws kept closed, the suture is drawn up out of the peritoneum, and a final inspection of the incision is performed to verify adequate closure and to ensure that no viscera or omentum is trapped within the closure. The suture may be placed and untied so that a trocar can be replaced for inspection of the surgical site or to assist with closure of other trocar sites. A conical introducer is available to maintain pneumoperitoneum and to assist with suture positioning.

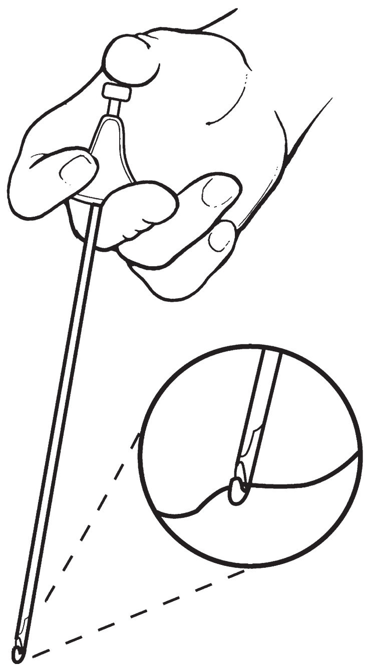

FIGURE 4–3. EndoClose suturing device (U.S. Surgical, Norwalk, CT). The spring-loaded stylet has a retractable hook that can grasp a suture when the top button is depressed. The EndoClose is inserted through one side of the incision, incorporating fascia. Depressing the top button releases the loop of suture. The EndoClose is reinserted (without suture) on the opposite side of the incision, incorporating the fascia. The notched end of the stylet is exposed, hooking the looped end of suture. Once the suture is hooked, the top button is released; the tip is thereupon drawn into the stylet and the suture is anchored. Then, the entire device is withdrawn above skin. A standard knot is tied.

obturator (Fig. 4–3). Release the button, drawing the hook and anchoring the suture at the tip of the device. Insert the EndoClose through one side of the incision, into the peritoneum, and then depress the button to drop the suture. A grasper placed through a second port can be employed to pull the suture farther down into the incision. Externally tag the ends of the suture to prevent tangling and to maintain orientation. Then reinsert the EndoClose device on the opposite side of the incision, through the fascia, and depress the button to expose the notched end of the stylet. Use the notched end to hook the loop of suture and draw it through the incision, making a standard hand-tied knot to finish the fascial closure.

J HOOK CLOSURE DEVICE

The J Hook closure device (Advanced Surgical, Princeton, NJ) is no longer readily available but may be found in some laparoscopic instrument sets. This instrument is constructed with a needle shaped like a fishing hook that rotates 180 degrees away from the shaft of the instrument.

Pass the J Hook into the 10-mm trocar site under direct vision; when the needle swings out, withdraw the device from the trocar. This action causes the needle tip with the suture eyelet to pierce the fascia. Load the suture into the eyelet, and reinsert the device. Rotate the needle handle 180 degrees to complete passage of the suture. Remove the trocar and J Hook devices and tie the sutures.

RADIALLY EXPANDING TROCARS

Radially expanding trocars (Step, Innerdyne, Sunnyvale, CA) represent a category of nonbladed trocars that develop incisions parallel to muscle fibers and a narrower tract. This blunt effect of the trocar placement results in not having to close the fascia even in incisions up to 12 mm.[4] Place the trocar by first applying an expandable mesh sleeve trocar over a Veress needle (Fig. 4–4*A*). Subsequently, pass a blunt-tipped fascial dilator through the mesh sleeve lumen (see Fig. 4–4*B*). Use the nondominant hand to stabilize the trocar with upward traction on the mesh sleeve while the fascial dilator and sheath are inserted. Use caution in placing these trocars because nonbladed trocars require more force for insertion.

FINAL SURVEY

After every laparoscopic procedure, conduct a careful and complete survey of the operative field. This is necessary to inspect for bleeding and unrecognized injury. Lower the pneumoperitoneum to a pressure of less than 5 mm Hg for 5 to 10 minutes to allow visualization of bleeding vessels that may have been occluded by higher working pressures during the procedure. Significant venous bleeding can occur once the abdominal pressure has been lowered to less than 5 mm Hg. Inspect the entire operative field to identify any previously unrecognized injury.

Use irrigation in an orderly and systematic fashion, if necessary, to wash the field for final inspection. Yellow or brown returned irrigation fluid may be a sign of an unrecognized bowel injury. Incisions larger than 5 mm require fascial closure in all patients in order to prevent bowel herniation. In children, close port sites smaller than 5 mm.

SEQUENCE OF TROCAR REMOVAL

Removal of the trocars using a specific routine each time is done for a few reasons:

1. Ensure adequate closure of the trocar sites
2. Assist with evacuation of the pneumoperitoneum
3. Possibly shorten the procedure time

The following sequence is recommended.

First, place all the fascial sutures at the 10/12-mm trocar sites. Initially, do not tie the sutures and re-place the trocars into the abdomen to maintain pressure for adequate visualization during closure and evacuation of the pneumoperitoneum. Remove the 5-mm trocars under direct vision, and inspect the sites under laparoscopic control for bleeding. Next, sequentially remove 10/12-mm trocar sites other than the camera site under direct vision, and tie the fascial sutures. Escaping gas from a

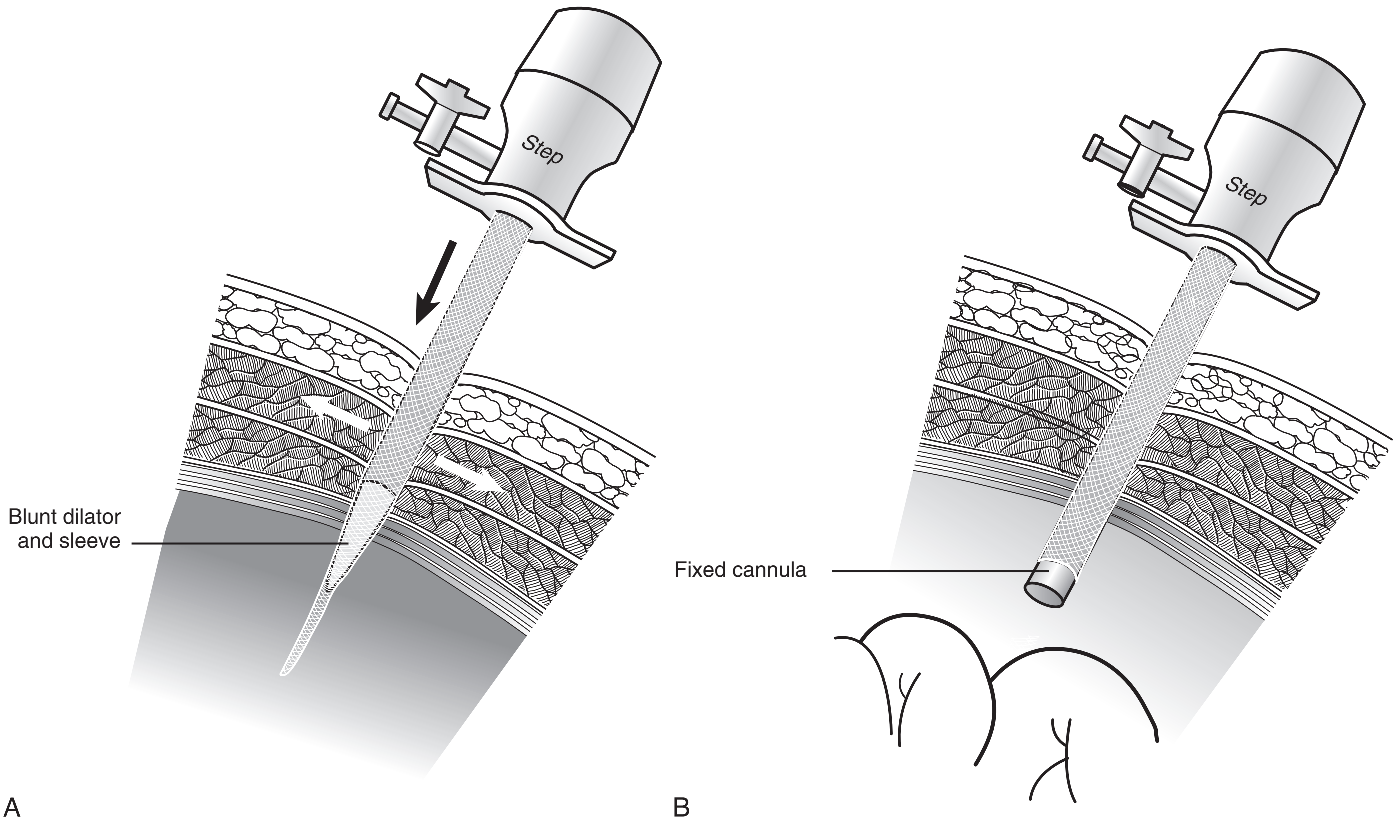

FIGURE 4–4. Radially expanding blunt-tipped trocar. *A,* First the expandable mesh sleeve trocar with Veress needle is inserted. Next, a blunt-tipped fascial dilator back-loaded with a trocar is inserted. *B,* Upward traction on the sleeve results in minimal downward traction of the abdominal wall during dilation. These trocars do not require fascial closure upon removal.

10/12-mm trocar site may indicate the need for additional sutures.

It is important that as much of the pneumoperitoneum be evacuated as possible before removal of the last trocar. When CO_2 is used as an insufflation agent, it is metabolized to carbonic acid and water on the peritoneal surface. Carbonic acid may cause diaphragmatic irritation, leading to postoperative shoulder, chest, or back pain. Residual pneumoscrotum or subcutaneous emphysema usually resolves within 24 to 48 hours.

Direct the last 10/12-mm trocar with the camera to the highest portion of the abdomen or working space, which harbors the greatest amount of gas (Fig. 4–5). Turn off the CO_2 and disconnect it from the trocar; make sure the trocar insufflation valve is in the open position to allow gas to escape. Apply external, manual pressure to the abdomen to help direct the gas to the trocar, evacuating a larger amount of intra-abdominal gas. In addition, the anesthesia team can use manual ventilation to assist in maximizing gas evacuation from the abdomen.

Pull up the previously placed fascial sutures to place tension on the wound edges; this maneuver will prevent herniation as the trocar and endoscope are removed. First, back out the trocar from the abdomen over the lens, leaving only the laparoscope in the abdomen. Then slowly remove the laparoscope, allowing inspection of the trocar tract for bleeding as the laparoscope is moved. Then secure the final fascial suture.

SKIN CLOSURE

Irrigate the trocar site and achieve adequate hemostasis of the skin edges before skin closure. After fascial closure, suture the skin with a subcuticular suture of 4-0 Vicryl on a cutting needle. Stapling is possible, although a better cosmetic result is obtained with a subcuticular suture.

SUMMARY

Closure of the abdominal cavity, inspection of the surgical field, and evacuation of residual CO_2 are important steps in every laparoscopic procedure. Trocar sites larger than 5 mm need to be closed in all patients. Closure of the fascia prevents herniation of omentum and abdominal viscera and dehiscence of wounds.[5] Patient habitus and laterally placed trocars may produce a difficult open closure. Therefore, it is important to be familiar with alternative techniques for closure.

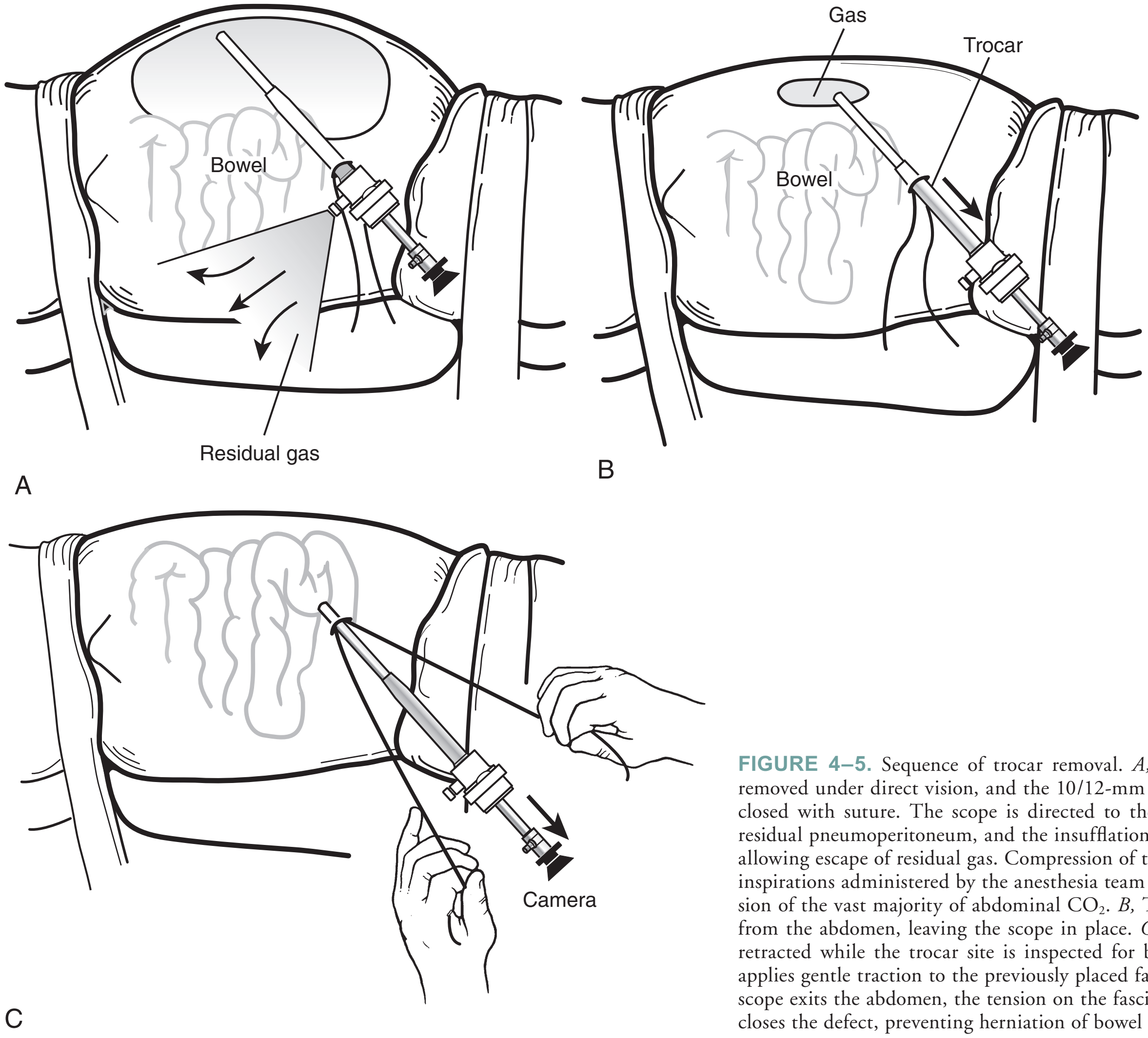

FIGURE 4–5. Sequence of trocar removal. *A,* All ports have been removed under direct vision, and the 10/12-mm trocar sites have been closed with suture. The scope is directed to the area containing the residual pneumoperitoneum, and the insufflation port is disconnected, allowing escape of residual gas. Compression of the abdomen and deep inspirations administered by the anesthesia team can assist with expulsion of the vast majority of abdominal CO_2. *B,* The trocar is retracted from the abdomen, leaving the scope in place. *C,* The scope is slowly retracted while the trocar site is inspected for bleeding. An assistant applies gentle traction to the previously placed fascial suture. After the scope exits the abdomen, the tension on the fascial suture immediately closes the defect, preventing herniation of bowel or omentum.

Tips and Tricks

- 2-0 Vicryl on a UR-6 needle can be used to close fascial incisions >5 mm.
- First pass of Carter–Thomason device starts on the side of the incision away from the camera to optimize visualization.
- Lower the pneumoperitoneal pressure at the end of the surgery to inspect for bleeding.

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CHAPTER 5

Laparoscopic Simple Nephrectomy

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Timothy D. Averch

In 1991, Clayman and associates[1] reported the first simple laparoscopic nephrectomy on a 54-year-old woman with oncocytoma. Since that revolutionary procedure, the indications for laparoscopic renal surgery have expanded, and laparoscopic nephrectomy has gained worldwide acceptance as the preferred approach for many pathologic conditions of the kidney. Laparoscopic approaches to renal surgery allow for the safe removal of renal units with the benefits of decreased narcotic analgesia requirements, shorter hospital stay, improved cosmesis, and earlier return to full activities compared with open approaches.[2] The use of this minimally invasive technique for the removal of benign renal pathology has been verified at several institutions.[3] The focus of this chapter is on simple laparoscopic nephrectomy via the intra-abdominal approach. The hand-assisted and retroperitoneoscopic approaches to nephrectomy can be applied to simple nephrectomy, but these methods are the subject of discussion in other chapters of this text.

INDICATIONS AND CONTRAINDICATIONS

Simple laparoscopic nephrectomy is an ideal method of treatment for many benign diseases of the kidney due to the appeal of decreased perioperative pain and morbidity. Indications for this procedure include removal of multicystic dysplastic kidneys, diseased kidneys causing renovascular hypertension, end-stage ureteropelvic junction obstruction, and nonfunctioning or chronically infected kidneys due to reflux nephropathy.

To date, there is less clarity on the role of laparoscopy in the removal of kidneys affected by severe inflammatory conditions and adult polycystic kidney disease. Series have been reported of laparoscopic simple nephrectomy for xanthogranulomatous pyelonephritis, tuberculosis, and other inflammatory conditions.[4] Advocates argue that laparoscopy, although more difficult in these cases, is possible and may result in improved outcomes in these patients.[5] However, critics suggest that the increased level of difficulty, increased operative times, and increased risk of complication and conversion to open procedure make laparoscopy in these patients unjustifiable.[4] Inarguably, inflammatory conditions of the kidney make hilar dissection more difficult, and these patients are at higher likelihood for conversion to open procedure. These procedures should be attempted only by the urologist with vast experience in laparoscopy and on patients who understand the increased risks compared with open procedures.

In patients with extensive history of prior abdominal surgery, the retroperitoneoscopic approach may be preferred. Abdominal cavities that have previously undergone surgery can present difficulties that increase operative time and complications. The retroperitoneal procedure gives the surgeon a more direct route to the diseased kidney while avoiding the potential adhesions and scar tissue.

Absolute contraindications to laparoscopic simple nephrectomy include uncorrected coagulopathy, untreated infection or sepsis, and hypovolemic shock.[6] Although morbid obesity is not a contraindication to laparoscopic surgery, obese patients may be at increased risk for complications and open conversion.[7]

PATIENT PREOPERATIVE EVALUATION AND PREPARATION

Preoperative evaluation for simple laparoscopic nephrectomy consists of complete blood cell count, measurement of clotting parameters, urinalysis, determination of serum electrolyte levels, and other tests as indicated depending on the patient's age and underlying comorbidities (e.g., electrocardiogram, chest radiograph).

A preoperative abdominal computed tomography (CT) scan is useful in evaluating the location, size, and disease of the kidney to be removed. Areas of perinephric stranding, discovered on CT scan, may indicate significant inflammation and dense adhesions, which may increase the chance that the laparoscopic procedure will have to be converted to an open procedure.[7] In addition, the scan will provide data on the vascular anatomy to the kidney, the kidneys' relationship to adjacent organs, and the function of the contralateral kidney.

OPERATING ROOM CONFIGURATION AND PATIENT POSITIONING

After the induction of general anesthesia, place an orogastric tube and a Foley catheter. Then roll the patient into the modified flank position with the side of interest up (i.e., for right-sided procedures, the patient lies on his or her left side). Place foam padding beneath all areas of stress due to contact with the operative table to avoid pressure injury. Place the umbilicus over the break in the table, and flex the table as seen in Figure 5–1. Use an axillary roll to prevent brachial plexus injury. Put the arms on an arm board with a pillow or rolled blankets between them. Bend the bottom-side leg and place a pillow or blankets between the legs so that the top leg rests nearly parallel to the table. Generously use 3-inch cloth tape to secure the patient at the hips and chest (see Fig. 5–1). Roll the table in each direction with personnel at each side of the table to ensure adequate stabilization of the patient. Perform a sterile

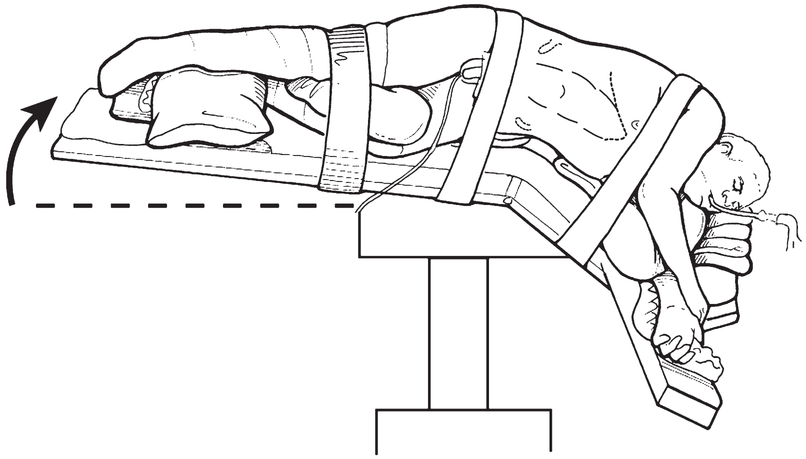


FIGURE 5–1. The patient is placed in a modified flank position. The umbilicus is placed over the break in the operating table and the patient is placed in a modified decubitus position with the hips and shoulders placed opposite the surgeon, as close to the far edge of the table as possible. This position allows the arms to be placed on the table in a “praying mantis” position or crossed over the chest with two pillows placed between them. Wide tape secures the chest and pelvis.

preparation over the entire abdomen in the event that conversion to open procedure is required. Make sure an open instrument tray is in the operating room and ready at all times should emergent conversion to open procedure be necessary.

TROCAR PLACEMENT

The Veress needle is placed at the site of the initial trocar, which is usually lateral to the rectus muscle on the side to be operated. With the patient situated in the lateral position, the bowel is displaced by gravity away from the site of the initial trocar. In patients with prior abdominal surgeries, place the Veress needle in a region away from prior surgical scars. To confirm intraperitoneal placement of the Veress needle, connect a syringe to the needle and aspirate. If there is no evidence of entry into bowel or a major blood vessel, perform the drop test by placing saline into the Veress needle and watching it freely drop into the peritoneal cavity. To further confirm appropriate location, begin insufflation at low flow rates. Place the insufflator on the high flow setting after even distribution of air to an enlarging, tympanitic abdomen and low intra-abdominal pressure are confirmed.

Once pneumoperitoneum is established, remove the Veress needle. Make a skin incision to accommodate a 12-mm trocar at the site of the needle puncture. Incisions that are too small can lead to use of excessive force to penetrate the abdominal fascia and, as a consequence, inadvertent trocar entry into underlying organs. Equally problematic are incisions made too large because they can lead to continuous air leakage and loss of pneumoperitoneum throughout the procedure. The visual obturator trocar is preferred by some because it provides direct visualization of the fascial layers to gain initial trocar access. Place the laparoscope through the initial port and directly examine the abdominal cavity for injury from entry as well as adhesions to the abdominal wall.

Three-trocar configurations are generally used for laparoscopic simple nephrectomy. Figure 5–2 shows examples of trocar placement for right- and left-sided procedures as well as for trocar placement in obese patients. Laterally shift the entire template in obese patients to allow for optimal instrument use.

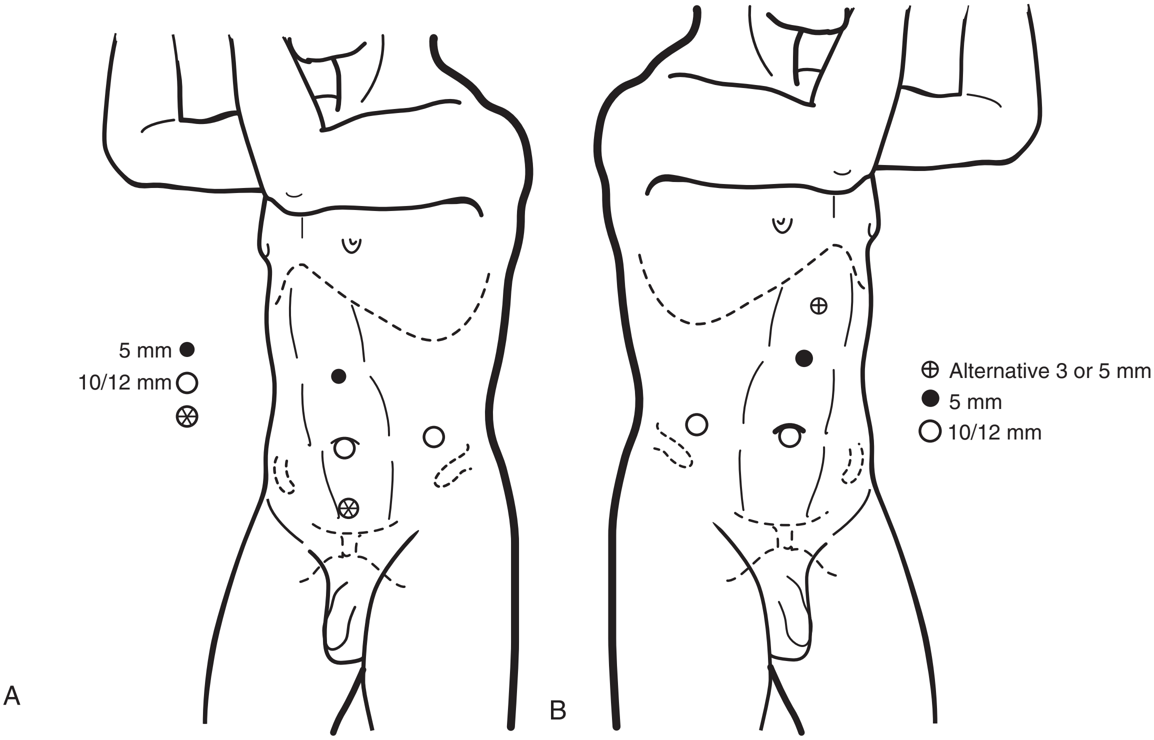
Place the secondary trocars under direct visualization so that the tip of the trocar is visualized in entirety as it penetrates the peritoneal lining. Place these ports in locations that are free of bowel adhesions, which are verified via direct visualization with the laparoscope. After placing the secondary trocars, take down adhesions with scissors or electrocautery. Various tools are available for dissection of tissues, including the hook electrocautery, laparoscopic scissors, harmonic scalpel, curved Maryland dissector, suction-irrigator, right-angle dissector, and atraumatic bowel graspers.

PROCEDURE

Reflection of the Colon

Place the patient in lateral position by rolling the operative table toward the surgeon. This position helps reflection of the colon medially by using gravity. With an atraumatic bowel grasper in the left hand, pull the colon medially. Use laparoscopic scissors in the right hand, if needed, and make an incision at the white line of Toldt lateral to the colon (Fig. 5–3). Take care to remain lateral enough to avoid damage to the colonic mesentery. Proper depth of the peritoneal incision is of utmost importance. Do not perform aggressive dissection posterior and lateral to the kidney at this part of the procedure. Concentrate on peeling the colon off the kidney at this time, rather than beginning to dissect the kidney away from the retroperitoneum. This is vital to further dissection because overaggressive posterior dissection will remove the attachments supporting the kidney against gravity during the dissection, making dissection of the hilum extremely difficult.

Make the line of the incision in the caudal direction to the bifurcation of the common iliac vessels and lateral to the spleen (left-sided procedures) or the liver (right-sided procedures) cranially (see Fig. 5–3). For left-sided procedures, the spleen can be troublesome due to its attachments to the kidney and abdominal wall. Minimal tension secondary to overaggressive retraction can lead to tearing of the splenic capsule. To avoid this, generously incise the attachments lateral to the spleen that are affixed to the abdominal wall contiguous to the spleen. After removing these attachments, place gentle medial traction on the spleen and carry out the dissection in the superior position. It is important to mobilize as much spleen as possible so that the spleen will fall medially along with the pancreas and colon. Be cautious to not incise too lateral to the spleen as the diaphragm can be injured.



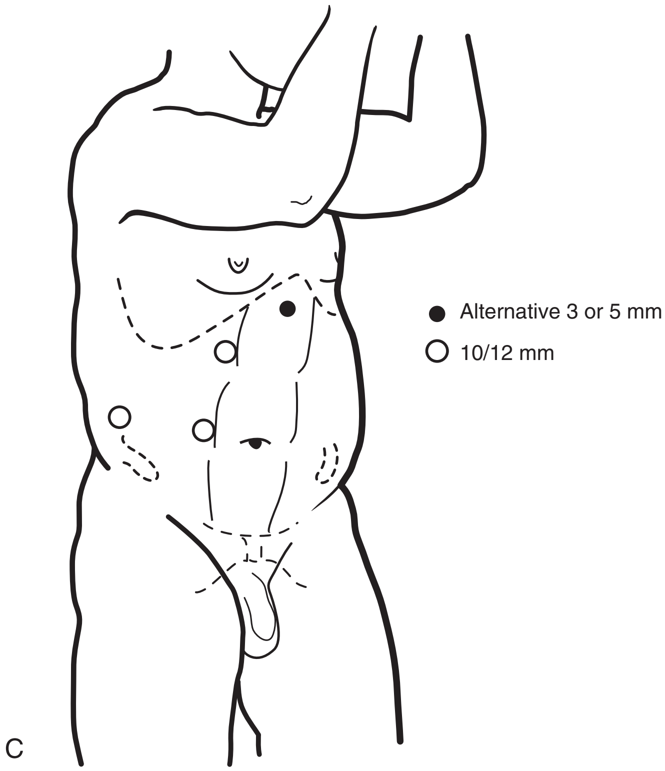


FIGURE 5–2. Trocar sites for (*A*) left-sided and (*B*) right-sided procedures. The first 10/12-mm trocar is placed lateral to the rectus at the level of the umbilicus and is used for dissection and placement of the endovascular GIA. A second 10/12-mm trocar placed at the umbilicus is used for placement of the laparoscope. A 5-mm trocar inserted in the midline between the umbilicus and the xyphoid process is used for placement of various dissecting instruments. *C,* In obese patients, all trocars are moved laterally.

For right-sided procedures, the white line of Toldt is incised inferiorly to the iliac vessels caudally as on the left side. The cranial extent of the incision follows a course lateral to the liver. While caution should be exercised when retracting the liver to avoid tearing the capsule, the liver is anatomically more mobile than the spleen, making the liver less susceptible to traction injury.

On either side, make the lateral incision in a Y shape with an incision proceeding superior to the kidney. This allows the lienocolic or heptocolic ligaments to be divided, further mobilizing the colon medially.

Dissection of the Ureter

The ipsilateral psoas muscle serves as a useful frame of reference in the localization of the ureter. The ureter is found at the medial aspect of the psoas, deep to the gonadal vein. Once the

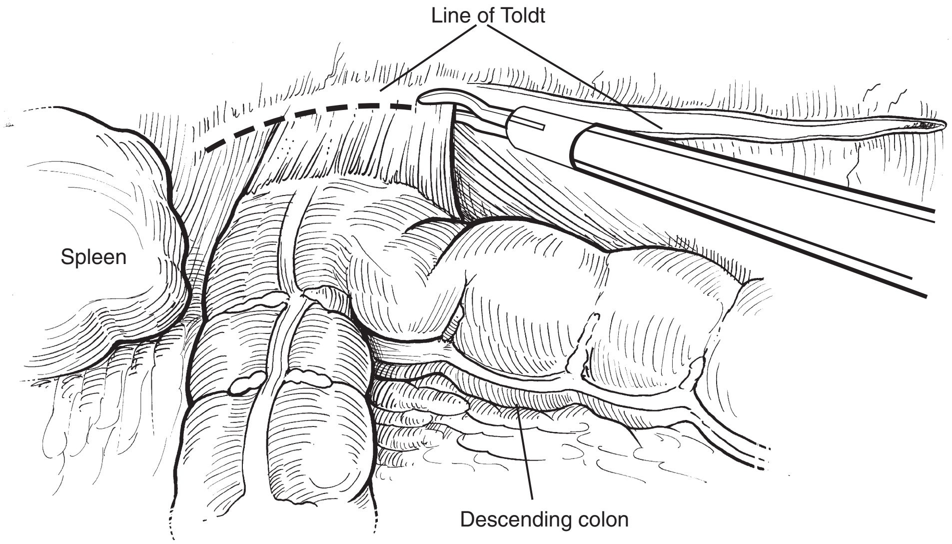


FIGURE 5–3. Incision of the white line of Toldt. The incision should be lateral to the colon to prevent inadvertent injury to the colon.

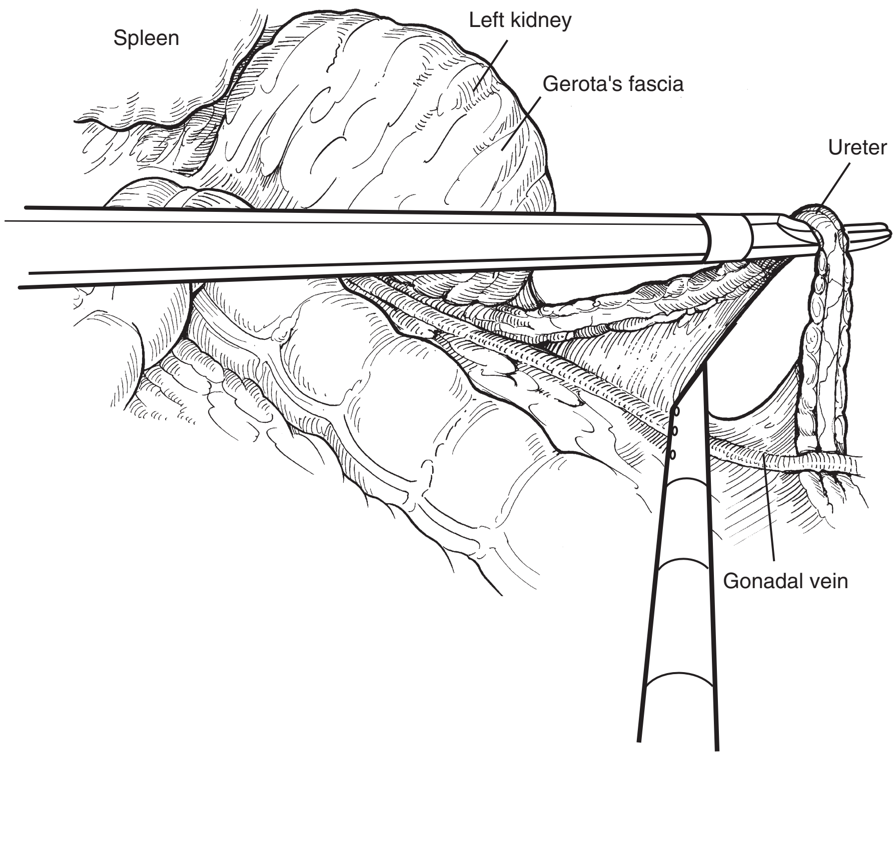


FIGURE 5–4. A curved dissector, in the left hand, is placed beneath the ureter and used to provide anterolateral elevation.

gonadal vein is identified, sweep it medially with blunt dissection and identify the ureter. Use a blunt dissecting device such as the suction-irrigator to create a window posterior to the ureter, and anteriorly elevate the ureter (Fig. 5–4). Continue the anterior elevation of the ureter cranially until the renal hilum is identified (Fig. 5–5).

Dissection of the Hilum

Localize the renal hilum by placing anterior traction on the ureter and following the ureter in a cranial direction via blunt dissection. For left-sided procedures, the gonadal vein is also a useful anatomic landmark because it drains directly into the

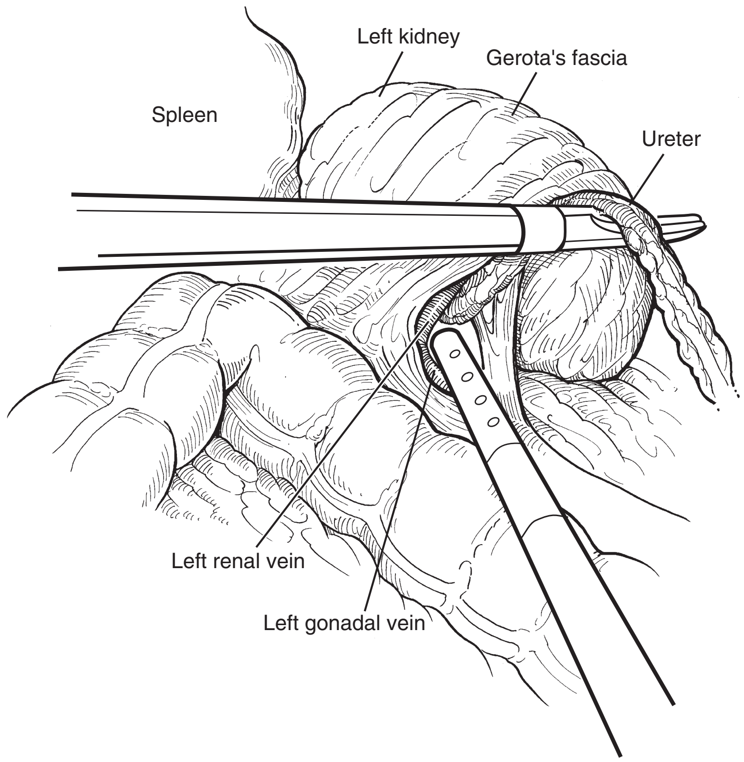


FIGURE 5–5. The ureter is followed to the lower pole of the kidney and then to the renal hilum. Thin medial attachments can be bluntly dissected with the tip of the irrigator-aspirator, revealing the edge of the renal vein.

left renal vein. Identify the renal vein and make an incision in Gerota's fascia anterior to the vein. After accessing the vein, dissect it in its entirety using caution to avoid inadvertent entry into the left adrenal vein (superomedial), the descending lumbar vein (posterior), or the gonadal vein (inferior). At this point, ligate the adrenal and gonadal veins using hemostatic clips (two clips on the proximal side and a single clip on the distal side of the incision).

For right-sided procedures, the gonadal vein is not as useful a landmark because it inserts directly into the inferior vena cava rather than the right renal vein. Thus, follow the ureter cranially to the renal hilum. The duodenum and inferior vena cava are situated directly medial to the right renal vein. Identify these structures and dissect them medially to prevent injury while isolating the renal vein. Also, avoid the adrenal gland, with its short adrenal vein entering the posterior surface of the vena cava, during dissection of the right renal hilum to prevent injury.

After isolating the renal vein, the focus of the dissection changes to the renal artery, which is found posterior to the renal vein. Indirectly place anterolateral traction on the kidney by lifting the suction-irrigator in the left hand after placing the device posterior to the ureter. Identify the renal artery posterior to the vein. Use a Maryland or right-angle dissector to separate the renal artery from the surrounding tissues. Once adequate length of the artery is established, apply metallic or Hem-o-lok (Weck Closure Systems, Research Triangle Park, NC) clips or an endovascular GIA to occlude the flow through the artery. Ligate the artery, leaving at least two hemostatic clips on the proximal end of the artery if clips are used. Upon occlusion of the renal artery, the kidney becomes uniformly ischemic in appearance and soft. The ipsilateral renal vein becomes decompressed and flat. If these findings do not occur, be suspicious that an additional renal artery or arteries may be present.

Most surgeons prefer the endovascular GIA to control the renal vein; however, extra-large Hem-o-lok clips may also be used (Fig. 5–6). If the endovascular GIA is used, squeeze the grip confidently and deliberately in a single, smooth motion. Partial or staccato squeezing can lead to misfiring and/or locking of the device while on the vein and potentially dire consequences. Also, the application of clips in the region of the hilum is discouraged because these can lead to malfunctioning of the GIA. Furthermore, when applying the GIA onto the vein, visualize the tips of the instrument and ensure that there is no tissue within the tines other than the renal vein.

Dissection of the Superior Pole

The ipsilateral adrenal gland is spared with simple laparoscopic nephrectomy except in cases in which the gland is densely adhered to the upper pole of the kidney. Before removing the ipsilateral adrenal gland, confirm the presence of a normal appearing contralateral adrenal gland on preoperative imaging.

Right-Sided Procedures

Free the upper pole of the right kidney from its peritoneal attachments by placing gentle superior traction on the liver. In cases in which the liver is extremely large or overlying the right kidney, place a fourth laparoscopic port to assist in retraction. Take care to avoid injury to the adrenal gland and its short vein to the posterior surface of the vena cava (Fig. 5–7). Connect the incision in the peritoneal attachments to that made lateral to the kidney during colon mobilization.

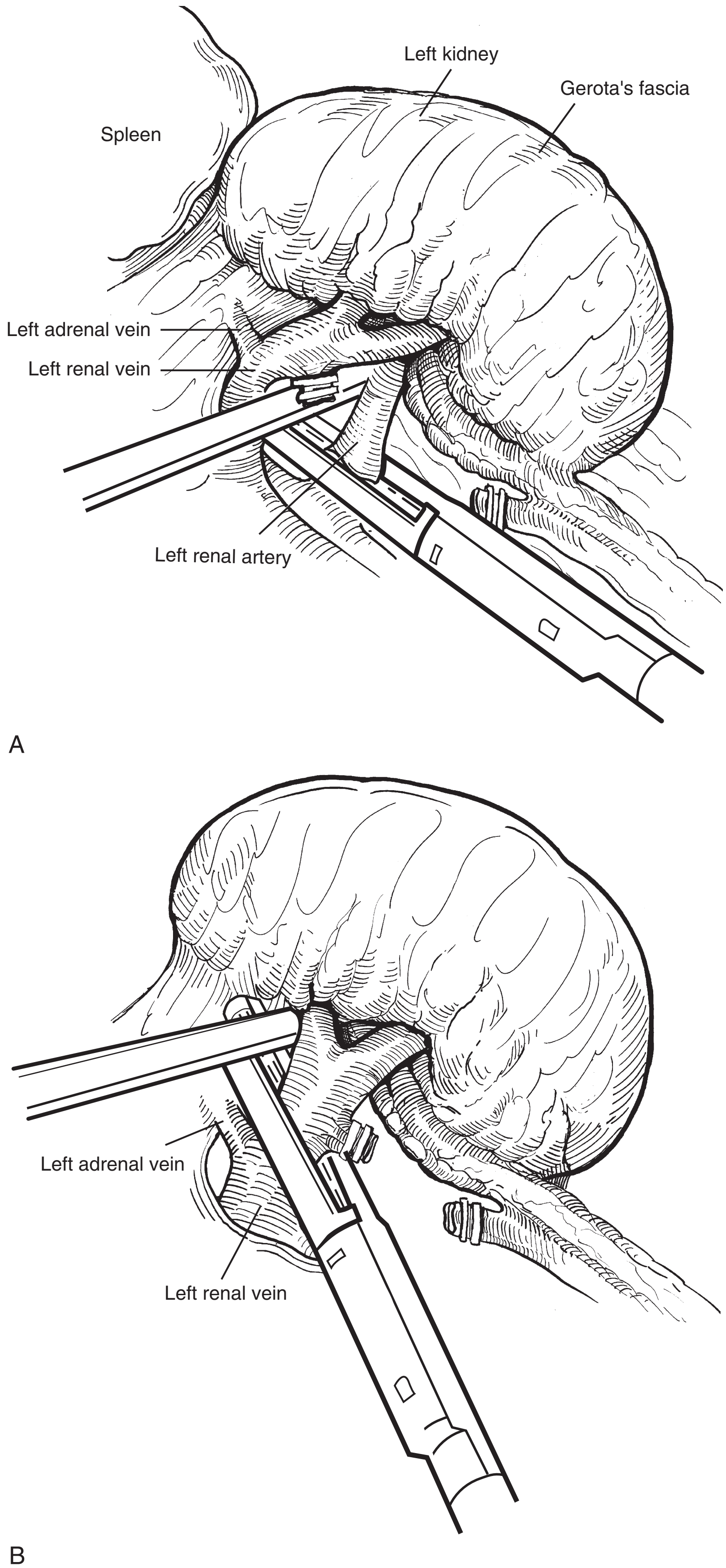


FIGURE 5–6. *A,* The artery is stapled first with the endovascular GIA. During this part of the procedure it may be helpful to place the retracting instrument between the renal artery and vein. This will provide more arterial length and separate artery from vein. *B,* The renal vein is ligated lateral to the adrenal vein with the endovascular GIA. During a simple nephrectomy, it is often possible to divide the renal vein lateral to the gonadal vein, leaving both the gonadal and adrenal veins intact.

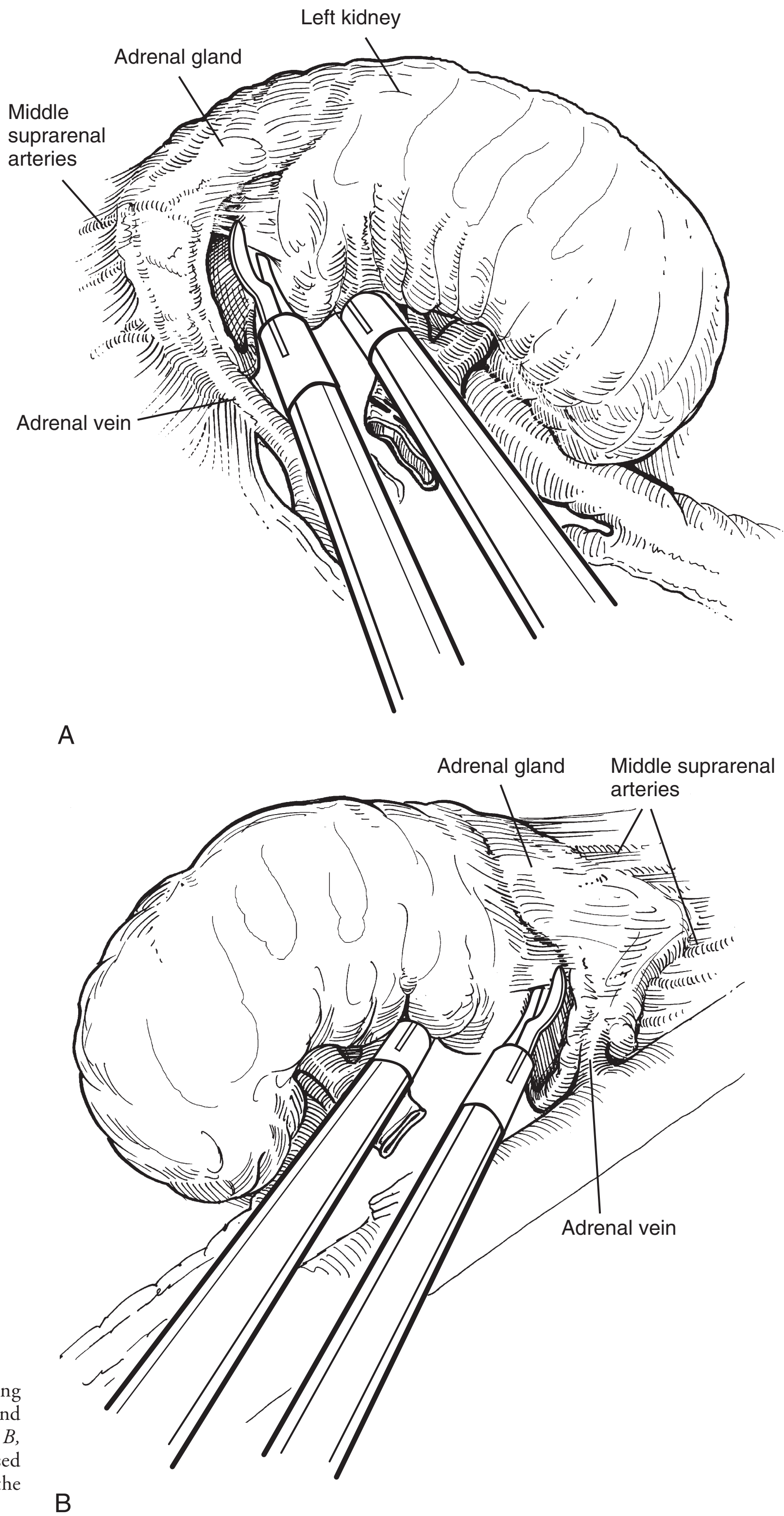


FIGURE 5–7. *A,* The left adrenal gland can be preserved during simple nephrectomy. Here, the left renal vein has been preserved and the dissection is continued directly on the capsule of the kidney. *B,* Preservation of the right adrenal gland. Caution must be exercised on the right so as not to avulse the short right adrenal vein from the vena cava.

Left-Sided Procedures

Superior pole dissection on the left side often poses greater challenges to the surgeon than right-sided procedures. The spleen, pancreas, adrenal gland, colon, and diaphragm are in intimate relation to the left kidney. The plane of dissection must proceed immediately adjacent to the upper pole of the kidney. The harmonic scalpel and a liberal amount of clips help in this dissection because problematic bleeding can be encountered in this region. Any retraction of the spleen must be gentle and superomedial. Retract the spleen only after adequate ligation of lienorenal attachments in order to prevent tearing of the delicate splenic capsule. Furthermore, it is important to dissect lateral to the spleen in a superior direction so that the spleen

can be safely retracted. Dissection should be in close proximity to the spleen and not too lateral to avoid injury to the diaphragm.

Incision of Gerota's Fascia and Ureteral Ligation

After ligating the renal vessels and dissecting the superior pole, direct the dissection toward freeing the kidney from Gerota's fascia. Perform a superior incision through this fascia so that the renal capsule is visualized. Sweep Gerota's fascia off the kidney by placing posterior tension on the kidney with a blunt instrument while sweeping the fascia anteriorly with the other. Continue the dissection by walking the instruments in a stepwise fashion through the developed tissue plane between the renal capsule and Gerota's fascia inferiorly and posteriorly. Leave the ureter intact until after removal of Gerota's fascia from the kidney because the ureter prevents rotation of the kidney and facilitates retraction. When the dissection is complete, double clip the proximal ureter with clips and make an incision between the clips. The kidney is now entirely freed from any attachments and prepared for removal.

Entrapment and Specimen Removal

Remove the surgical specimen either intact or morcellated. Carry out morcellation by placing a sturdy impermeable bag through the umbilical port. The LapSac (Cook Urological, Spencer, IN) is adequate for this purpose. Place the kidney inside the bag and morcellate with either the electronic morcellator or manual ringed forceps. Easily remove the bag containing the morcellated contents through the umbilical port incision.

Alternatively, place the specimen in a specimen retrieval bag such as the EndoCatch (U.S. Surgical Corp, Norwalk, CT) via an extension of the umbilical port incision. Make an infraumbilical midline incision through the rectus fascia. Then close the laparoscopic ports with absorbable suture using a Carter-Thomason CloseSure (Inlet Medical Inc., Eden Prairie, MN) device. Place a hand through the extraction incision if possible to prevent puncture injury to the underlying bowel by the closure tool.

POSTOPERATIVE MANAGEMENT

At the conclusion of the procedure, awaken the patient and remove either the orogastric or the nasogastric tube. Start clear liquids once the patient is fully awake, and gradually advance the diet to regular, as tolerated by the patient. Intravenous administration of ketorolac helps reduce the patient's discomfort and need for narcotic analgesia. The patient begins early ambulation to prevent formation of deep venous thrombosis as well as postoperative pulmonary problems. Obtain serum electrolytes the morning of postoperative day 1 as well as hemoglobin in cases of excessive blood loss during the procedure.

COMPLICATIONS

Be aware of the numerous complications of simple laparoscopic nephrectomy to promptly recognize and treat them should they arise.

Major vessel injury can occur with placement of the Veress needle or laparoscopic trocars. This injury is typically immediately noticed by seeing pulsatile blood return through the Veress needle or trocar. Open control and repair is an ideal approach to these injuries because blood loss can be severe and rapid.

Bowel injury is another potential complication and is, unfortunately, rarely recognized at the time of surgery. Patients with bowel injury present with port-site redness and tenderness, leukopenia, and diarrhea in the postoperative period. Perform abdominal CT scan if these signs are present.

Air embolism manifests as sudden hypoxia, hypercarbia, and a characteristic "mill-wheel" cardiac murmur. Once air embolism is recognized, place the patient in the head-down, right-side up position and evacute the embolism by central venous catheter.

Oliguria is common with pneumoperitoneum; discourage use of urine output as an indicator of intravascular volume status. Make the anesthesia team aware of this phenomenon so that the overadministration of intravenous fluids and the subsequent development of pulmonary edema do not occur.

Rhabdomyolysis can occur after prolonged procedures and has been associated with use of beanbag appliances used for patient stabilization. This complication can be minimized with liberal padding of all areas that come in contact with the operative table.

Additional complications include incisional hernia after intact specimen removal, prolonged ileus, pneumonia, pulmonary embolism, and brachial nerve injury.

SUMMARY

Laparoscopic simple nephrectomy is a feasible and effective treatment option for benign renal pathologic conditions. This procedure offers shorter hospital stay, decreased use of narcotic analgesia, better cosmesis, and earlier return to full activity when compared with the open approach. The steps provided herein can be applied to remove most benign conditions of the kidney. Xanthogranulomatous pyelonephritis, tuberculosis, and other inflammatory conditions should be treated laparoscopically only by experienced hands.

Tips and Tricks

- Careful positioning of the patient is essential to a successful procedure. Do not rush or neglect this aspect of the procedure.
- Ensure that the patient is adequately padded at all areas of contact with the operative table to prevent nerve injury, pressure sores, and rhabdomyolysis.
- If deciding to remove the ipsilateral adrenal gland, always stop to ensure that a contralateral adrenal gland exists.
- The ureter is a valuable retractor. If left intact, a blunt instrument can be used to elevate the ureter, and thus the lower pole of the kidney, allowing the surgeon to progress to the renal hilum.
- The harmonic scalpel is an indispensable instrument for dissection of the adrenal gland from the kidney as it controls bleeding from small vessels to the adrenal.

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CHAPTER 6

Laparoscopic Radical Nephrectomy

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J. Kyle Anderson
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For patients with clinically localized renal cell carcinoma, surgery provides the best opportunity for cure. Evidence also suggests that patients with locally advanced or metastatic renal cell carcinoma may benefit from laparoscopic cytoreductive nephrectomy.[1] Laparoscopic radical nephrectomy was first described by Clayman and associates in 1991[2] as an alternative to open surgery. Since that time, it has developed into the preferred approach for kidney removal in appropriately selected patients. The perioperative benefits of the procedure are well established, and several studies have demonstrated that the disease-free and cancer-specific survival rates for laparoscopic radical nephrectomy are comparable to those for open surgery.[3]

Laparoscopic radical nephrectomy can be performed by using either a transperitoneal or a retroperitoneal approach. This chapter describes the more widely used transperitoneal technique. The hand-assisted technique is not discussed. The transperitoneal approach provides excellent visualization of the abdomen and retroperitoneum, uses familiar anatomic landmarks, and compared with the retroperitoneal approach, offers a larger working space with no increase in morbidity.

INDICATIONS AND CONTRAINDICATIONS

Laparoscopic radical nephrectomy is indicated in clinically staged T1 and T2 tumors. Generally, the technique is used for tumors smaller than 10 cm in diameter, but skilled laparoscopists have successfully removed 12- to 18-cm tumors laparoscopically. Tumors that are shown on preoperative imaging studies to extend beyond the renal capsule (T3a) may also be removed laparoscopically if size limitations permit.

Relative contraindications to laparoscopic radical nephrectomy include tumors with renal vein or vena cava tumor thrombi. Although multiple case reports have described approaches to thrombectomy, reliable and reproducible methods of performing a laparoscopic thrombectomy are being investigated. Also, renal cell carcinoma that extends beyond Gerota's fascia is difficult to remove laparoscopically. Laparoscopic radical nephrectomy must be approached cautiously in patients with a prior history of ipsilateral renal surgery, perinephric inflammation, or extensive intra-abdominal surgery. The decision to proceed with laparoscopic radical nephrectomy in these patients is made on a case-by-case basis, depending on the experience of the surgeon and with the realization that conversion to open surgery may be necessary.

PATIENT PREOPERATIVE EVALUATION AND PREPARATION

The preoperative evaluation of a patient with a suspected renal malignancy is the same whether an open or a laparoscopic approach is planned. Perform routine laboratory studies as indicated. The metastatic evaluation includes a chest radiograph or computed tomography (CT) scan and an abdominal CT. A bone scan is generally reserved for patients with elevated serum calcium or alkaline phosphatase levels and those with symptomatic bone pain. If there is a question of renal vein tumor thrombus, use an appropriate study (magnetic resonance imaging, venography, sonography, or three-dimensional CT) to evaluate the vein preoperatively.

Assess contralateral renal function before radical nephrectomy. Serum creatinine levels and organ appearance on contrast-enhanced CT should suffice. In equivocal cases, a functional renal scan and 24-hour urinary creatinine clearance studies may be necessary, and consider a partial nephrectomy.

For the less experienced surgeon, prior knowledge of the renal vascular anatomy can be helpful. Although an arteriogram may be performed before the procedure, a three-dimensional reconstruction of the abdominal spiral CT provides reliable images of the renal arterial and venous anatomy.

Patient preparation begins with informed consent. Always inform the patient undergoing laparoscopic surgery that the potential exists for conversion to an open procedure. Depending on the surgeon's experience, the conversion rate is generally less than 5%.

Bowel preparation is not necessary, but many surgeons prefer to order a bowel regimen to help decompress the colon during the transperitoneal approach. Patients undergo blood typing and screening. Obtain autologous or cross-matched blood, depending on the personal experience and patient preference. Finally, administer a broad-spectrum antibiotic, such as cefazolin, before the patient is taken to the operating room.

OPERATING ROOM CONFIGURATION AND PATIENT POSITIONING

The operating room configuration includes two monitors to allow visualization of the procedure by all members of the surgical team. The surgeon and the camera holder stand on the contralateral side, facing the patient's abdomen, and the scrub nurse and any other assistant stand facing the patient's back.

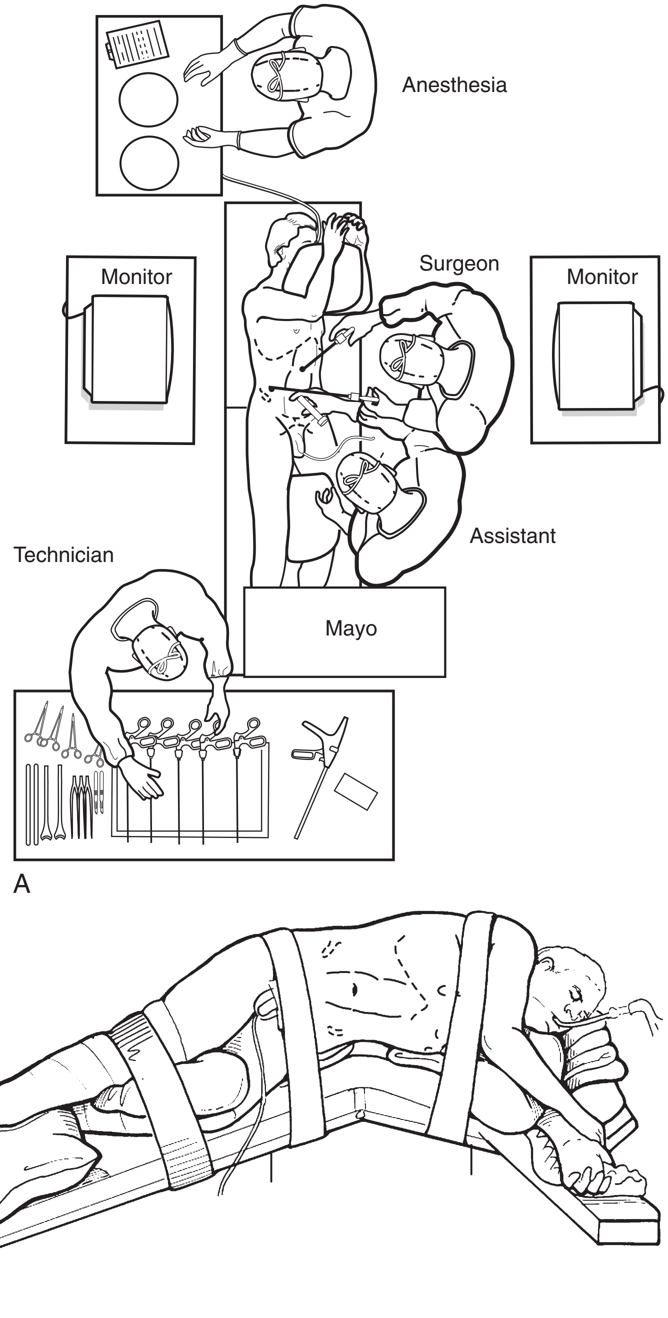


FIGURE 6–1. *A,* The operating room configuration includes two monitors, allowing visualization of the procedure by all members of the surgical team. The surgeon and camera holder stand on the contralateral side, facing the patient's abdomen; the scrub nurse and any other assistant stand facing the patient's back. Mayo, Mayo instrument table; Tech, surgical technician. *B,* The patient is positioned in a 30-degree modified decubitus position. The posterior iliac crest overlies the kidney rest, and the arms are flexed in a "praying" position. Pillows or an elevated arm board support the ipsilateral arm. Care is taken to pad all potential pressure points, including the contralateral elbow and both legs and ankles. An axillary roll may be needed to protect the brachial plexus of the contralateral arm.

Position the primary monitor across the table from the surgeon at the level of the patient's chest (Fig. 6–1*A*).

After the induction of general anesthesia and endotracheal intubation, place an orogastric tube and bladder catheter. Reposition the patient in a 30-degree modified decubitus position (see Fig. 6–1*B*). The posterior iliac crest overlies the kidney rest; flex the arms in a "praying" position. Use pillows or an elevated arm board to support the ipsilateral arm. Take care to pad all potential pressure points, including the contralateral elbow and both legs and ankles. An axillary roll may be needed to protect the brachial plexus of the contralateral arm.

Flex the table as necessary approximately 30 to 45 degrees to widen the distance between the ipsilateral costal margin and the iliac crest. The kidney rest is generally not used. Finally, secure the patient to the table with wide tape over the legs, hips, and shoulders. This step allows the table and patient to be rotated safely during the procedure as necessary. Test rotation before surgical preparation and draping of the patient. Surgically prepare the skin from the nipples to the pubis and from the contralateral rectus muscle to the paraspinal muscles.

TROCAR PLACEMENT

The table is rotated away from the surgeon. Obtain peritoneal insufflation with a Veress needle inserted at the umbilicus. Alternatively, insert the Veress needle into the midclavicular line between the anterior iliac crest and the umbilicus. Use CO_2 insufflation to maintain a pressure of 15 mm Hg, although

20 mm Hg is often necessary to ensure a tense pneumoperitoneum during port placement and dissection.

Three ports are generally sufficient to complete the procedure; a fourth trocar may be necessary for organ entrapment and liver retraction during right nephrectomy. Place the first 10/12-mm trocar through a periumbilical incision. Because the endovascular staplers used to divide the hilar vessels require a 12-mm port, confirm that the 10-mm trocars are able to accommodate a 12-mm instrument. We prefer to obtain this initial access with the Visiport device (U.S. Surgical Corporation, Norwalk, CT), which permits endoscopic visualization while the trocar is introduced. Then place a second 10/12-mm trocar in the ipsilateral midclavicular line just slightly caudal to the level of the umbilicus (lower abdominal quadrant port) under direct vision. Place the third, 5-mm, port just above the midpoint between the umbilicus and xiphoid.

For a right-sided nephrectomy, an optional fourth port of 3 or 5 mm may be used to assist with specimen retraction, liver elevation, or organ entrapment (Fig. 6–2*A*). Place this port, after the colon is entirely mobilized, in the midline between the upper trocar and xiphoid.

Trocar placement for left-sided nephrectomy is similar to that for a right-sided procedure. Place two 10/12-mm trocars at the umbilicus and the ipsilateral midclavicular line just caudal to the level of the umbilicus. Place a 5-mm trocar just above the midpoint between the umbilicus and the xiphoid process in the midline. If needed, place an additional 5- or 10-mm trocar above the symphysis pubis in the midline for medial bowel retraction (see Fig. 6–2*B*).

In a tall or obese patient, this port scheme may make it difficult to reach the lateral and superior margins of the specimen. In morbidly obese patients, move all ports more lateral (see Fig. 6–2*C*). In tall patients, move all trocars more cephalad. These measures ensure that the instruments can access the entire specimen and complete the dissection.

Consider securing each trocar to the abdomen with a 2-0 suture to prevent inadvertent withdrawal during instrument removal. Operate through the epigastric and the lower quadrant ports while the assistant holds the laparoscope in the umbilical port. If a port is needed for lateral retraction, it is also manipulated by an assistant.

PROCEDURE

After placement of the laparoscopic ports, a radical nephrectomy involves the following steps:

1. Incise the line of Toldt and mobilize the colon.
2. Identify and secure the ureter.
3. Mobilize the lower pole of the kidney within Gerota's fascia.
4. Secure the hilar vessels.
5. Dissect the upper pole with or without the adrenal gland.
6. Dissect the lateral attachments.
7. Divide the ureter.
8. Observe for hemostasis.
9. Entrap the specimen.
10. Remove the intact specimen through a small incision (or morcellize the specimen).
11. Close the incision and trocar sites as needed.

A description of the right-sided radical nephrectomy is presented, with important variations for a left-sided procedure clearly detailed.

Mobilizing the Colon

Use a 5-mm electrosurgical scissors and a 5-mm atraumatic forceps to identify and incise the ipsilateral line of Toldt (Fig. 6–3). Alternatively, use 5-mm ultrasonic (US) dissection devices in place of the electrosurgical scissors. Rotating the table toward the surgeon allows gravity to facilitate identification of the line of Toldt and to mobilize the colon. Incise this lateral colonic peritoneal reflection on the right, from the right common iliac artery to the hepatic flexure. The anterolateral surface of the right kidney is often not entirely behind the ascending colon and is usually covered by the lateral peritoneum. Therefore, during incision of the line of Toldt cephalad, leave the peritoneum overlying the lateral and upper poles in situ, and only mobilize the colon. Leave a swath of peritoneum overlying the anterior surface of the kidney. Carry the incision medially around the hepatic flexure between the liver and the transverse colon to allow full mobilization of the entire ascending colon. Divide the right triangular and anterior coronary ligaments of the liver, also. Then sharply divide the colorenal attachments to allow the ascending colon and hepatic flexure to be rolled medially (Fig. 6–4). Expose the duodenum and then sharply mobilize it medially, by means of the Kocher maneuver, until the vena cava is clearly visualized (Fig. 6–5).

During a left-sided radical nephrectomy, incise the line of Toldt in a similar fashion from the left common iliac artery to the splenic flexure. The left kidney is usually entirely within the retroperitoneum, so that little or no peritoneum is left overlying the specimen after the line of Toldt is incised. Carry the incision medially around the splenic flexure, dividing the phrenicocolic and splenorenal ligaments entirely. Sharply divide the colorenal attachments to enable the descending colon and splenic flexure to be rolled medially until the anterior surface of the aorta is visualized (Fig. 6–6). Incision of the splenophrenic attachments allows the spleen to be rolled medially; this facilitates upper pole dissection.

When starting the incision and developing the retroperitoneal space, place the peritoneum and underlying colon under gentle tension with the atraumatic forceps. Then, with either 5-mm electrosurgical scissors or US scissors, safely cut the peritoneum and small vessels. After incising the line of Toldt and corresponding colonic flexure, medially mobilize the colon in a blunt fashion. The blunt-tipped 5-mm irrigator-aspirator is very useful for this maneuver. Incise colorenal attachments either sharply or with the electrocautery; this is best visualized by gentle medial retraction on the colon. Continuously be aware of the colonic mesentery's location to avoid so-called button-holing and the creation of a mesenteric hematoma or later a site for herniation of small bowel. Take care when using electrocautery near bowel to avoid thermal injury.

Identifying and Securing the Ureter

Initial identification and securing of the ureter facilitates later dissection of the lower pole and renal hilum. The midureter is located in the retroperitoneal fat medial to the psoas muscle. During proximal mobilization, the gonadal vein is often encountered. The ureter is located just lateral and deep to this

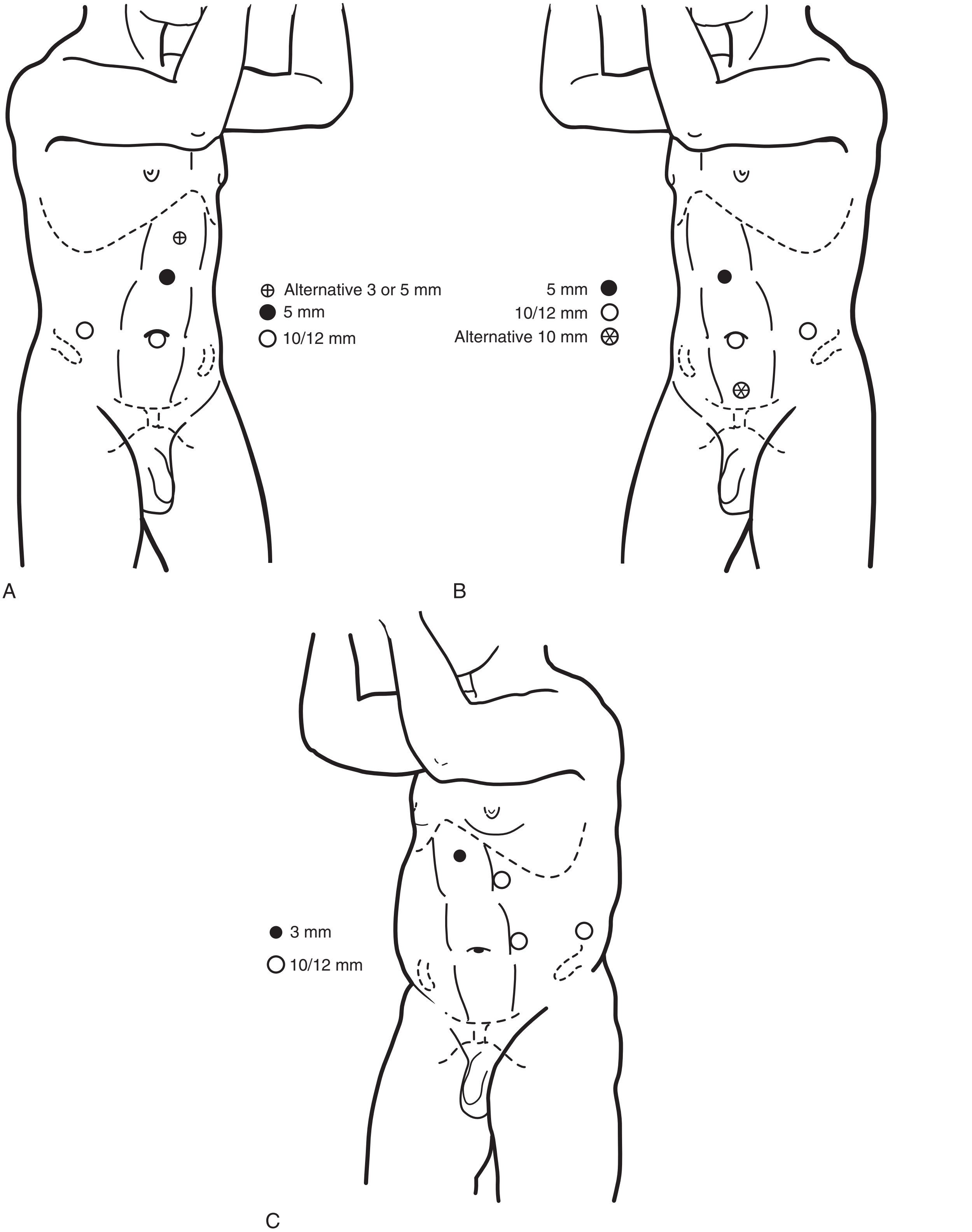


FIGURE 6–2. *A,* Port placement for a right nephrectomy. An optional fourth port (5 or 3 mm) to assist with liver retraction may be placed below the costal margin in the midclavicular line or in the midline below the xiphoid. *B,* Port placement for a left nephrectomy. An optional fourth port to assist with specimen elevation or medial retraction of the bowel is placed either in the midclavicular line below the costal margin (5 or 3 mm) or in the midline above the symphysis (10 or 5 mm). *C,* Port placement in the obese patient. The same configuration is used except that all primary trocars are positioned lateral to the rectus muscle.

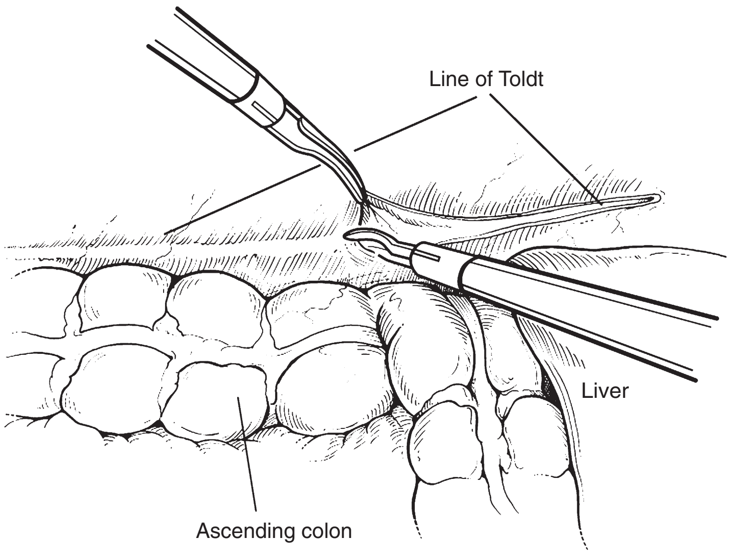


FIGURE 6–3. Incising the line of Toldt and reflecting the colon medially commences exposure of the specimen. In this illustration, the ascending colon is mobilized for a right-sided nephrectomy.

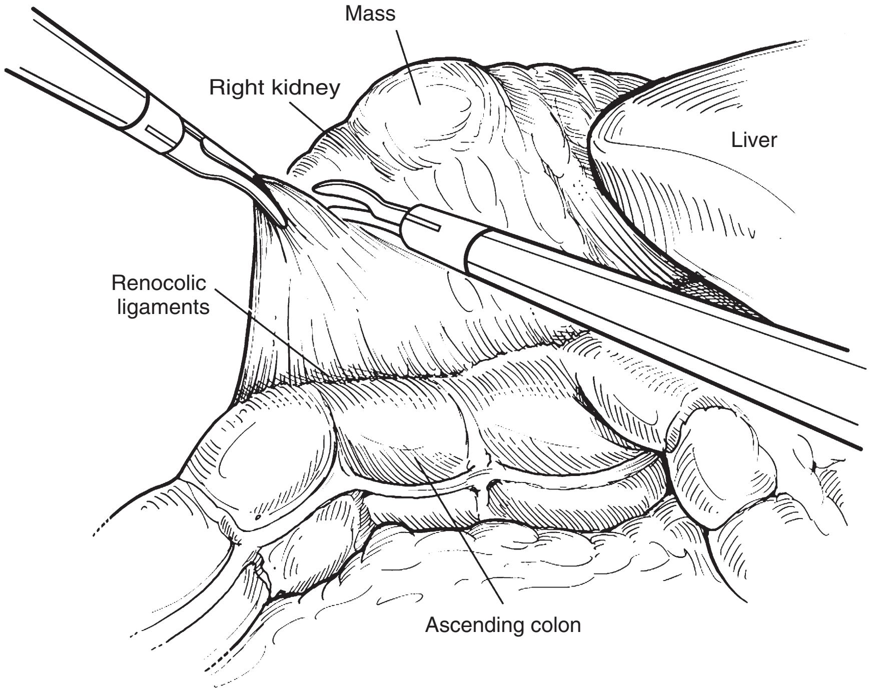


FIGURE 6–4. Division of the colorenal attachments in a right-sided nephrectomy allows full reflection of the ascending colon, gives access to the retroperitoneum, and exposes the duodenum. Sharp and blunt dissection is best used to release the colon medially.

structure (Fig. 6–7). Laterally elevate the ureter and proximally mobilize it. Do not divide the ureter at this point because superior and lateral elevation of the intact ureter aids in the exposure of the renal hilum.

Occasionally, identification of the ureter can be difficult. In general, the ureter is located more medially than anticipated and systematic inspection of the retroperitoneum from the great vessels laterally may be necessary. Alternative ureteral identification techniques include the following:

1. Identify and follow the gonadal vessels that course anterior and lateral to the midureter
2. Stroke or pinch the retroperitoneal fat with the atraumatic forceps to look for ureteral peristalsis
3. Search for the ureter where it crosses the iliac vessels

Mobilizing the Lower Pole Within Gerota's Fascia

Unlike a simple nephrectomy, the renal parenchyma should never be seen during the operation. Once the ureter is mobilized up to the ureteropelvic junction, insert 5-mm forceps beneath Gerota's fascia and lower pole along the psoas fascia. Superolaterally lift the specimen, and bluntly divide the inferior and posterior side wall attachments with the irrigator-aspirator and electrosurgical scissors (Fig. 6–8). Divide the inferior cone of Gerota's fascia lateral to the ureter now. Preserve a generous amount of inferior perirenal fat with the specimen. Do not divide the ureter at this time in order to prevent the specimen from inadvertently pivoting during the hilar and posterior dissection, which would obscure the endoscopic view.

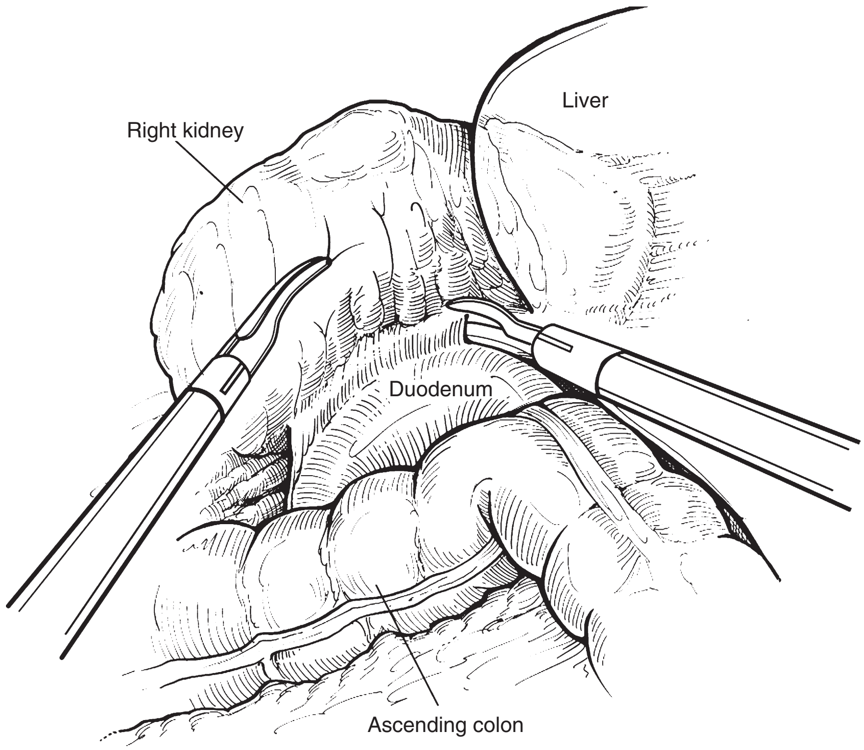


FIGURE 6–5. In a right-sided radical nephrectomy, the duodenum may be encountered after the colorenal attachments are divided. To expose the renal hilum, which invariably lies posterior to the second portion of the duodenum, a Kocher maneuver is employed. Electrocautery must be used judiciously to avoid duodenal injury.

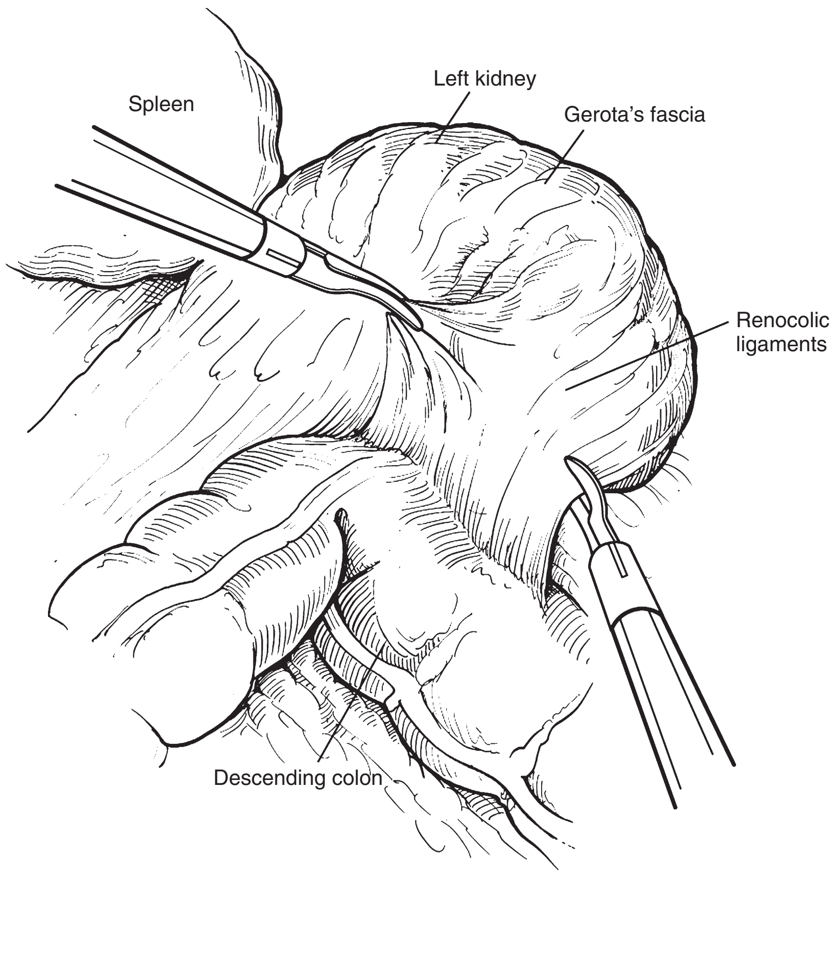


FIGURE 6–6. Division of the colorenal attachments during a left-sided nephrectomy allows full reflection of the splenic flexure and descending colon, as well as access to the retroperitoneum. Sharp and blunt dissection is employed to release the colon medially.

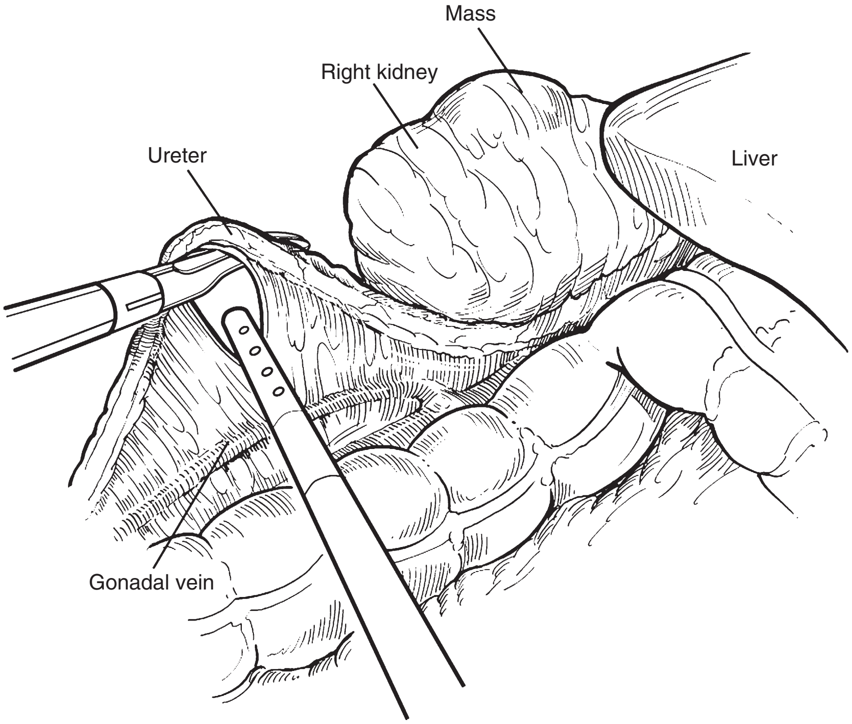


FIGURE 6–7. The ureter and gonadal vein are elevated with a grasper and mobilized cephalad. Blunt dissection with the irrigator-aspirator facilitates this maneuver. Any ureteral vessels encountered should be divided between clips.

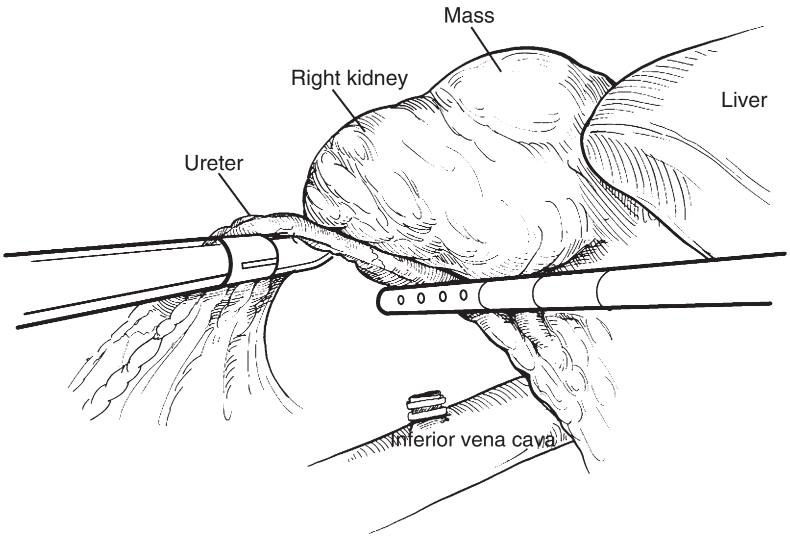


FIGURE 6–8. As the cephalad dissection approaches the renal hilum, the gonadal vein crosses anterior to the ureter. On the right, the gonadal vein should be divided between clips at its confluence with the inferior vena cava. On the left, the vein should be divided between clips at its confluence with the left renal vein. The lower pole of the kidney within Gerota's fascia should then be bluntly mobilized through elevation of the ureter and specimen.

To facilitate this dissection and assist with the lateral retraction of the specimen during the hilar dissection, a fourth port may be needed, as described earlier.

Securing the Hilar Vessels

The most critical and hazardous step in the operation is the hilar dissection. The goal is to dissect the renal arteries and veins individually. To minimize the number of vessels to be divided and to avoid bleeding from hilar branches, perform this dissection as close as possible to the vena cava on the right and to the aorta on the left.

Place the renal hilum on gentle tension by lifting the lower pole laterally and superiorly. Using the electrosurgical scissors and the irrigator-aspirator, identify the hilum by moving cephalad along the medial aspect of the ureter and renal pelvis. The entire hilum, but in particular the renal artery, is usually enveloped in dense lymphatic and neural tissue. This tissue is best divided between clips or with the US scalpel or electrocautery. However, care should be taken to avoid placement of excessive clips as the clips can interfere with the endovascular staplers employed to divide the vessels.

The renal vein is usually identified first and is dissected circumferentially. On the left side, the gonadal vein must be identified and divided between a pair of double clips. The lumbar vein usually can be left alone as the renal vein is divided distal to the lumbar insertion. The left adrenal vein is preserved if the ipsilateral adrenal gland is to be spared. In this situation,

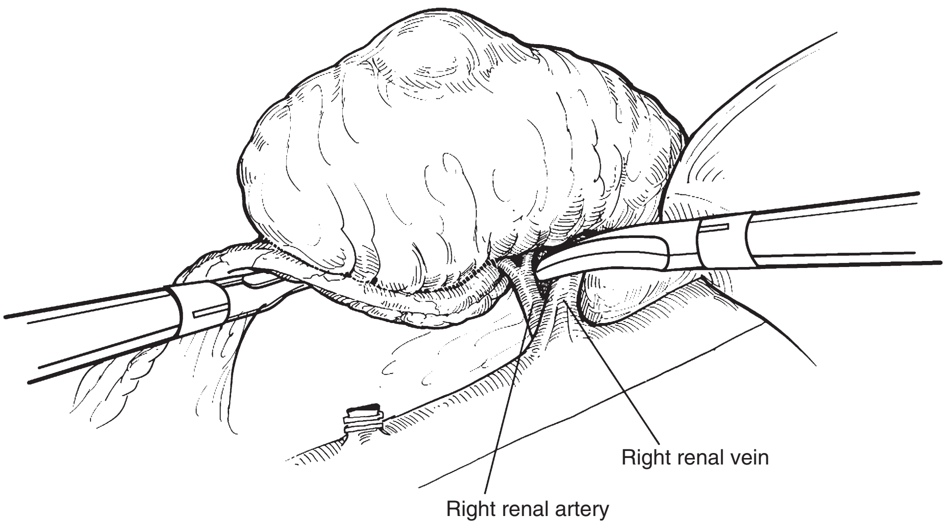


FIGURE 6–9. After mobilization of the lower pole and posterior attachments, the renal hilum is exposed. The renal artery is generally posterosuperior to the renal vein. The vein is lifted anteriorly to expose the artery, and a plane is dissected to allow the introduction of the endovascular GIA stapler.

the renal vein is divided distal (lateral) to its confluence with the adrenal vein. After the renal vein is dissected, the renal artery is identified and similarly dissected. Often, the renal vein must be lifted anteriorly to expose the artery (Fig. 6–9). There is no need to completely skeletonize these vessels when using an endovascular GIA stapler because the device will also occlude and transect perivascular lymphatic and fatty tissue.

After identifying the renal vessels, pass a 10-mm endovascular GIA stapler through the 10/12-mm lower quadrant port. Occlude and divide the artery first, then the vein (Fig. 6–10*A*, *B*). It is critical that the jaws of the stapler be advanced over the entirety of the vessel to ensure complete occlusion and division. An alternative to stapling is to apply locking clips on the artery. In this case, the entire renal artery must be skeletonized. Dividing the entire hilum (vein and artery) with a single stapler can risk formation of an arteriovenous fistula and should be avoided if possible. This complication, however, is rare and complete hilar transection with a stapler is often performed in cases of dense hilar fibrosis.

Often, the hilar dissection is encumbered by bowel falling into the operative field. Rotating the operating table to further elevate the ipsilateral side allows the abdominal contents to fall medially and usually exposes the hilum sufficiently. Occasionally, during left-sided nephrectomy, additional retraction is necessary. In such cases, insert a 10-mm port in the midline several centimeters above the symphysis. Position a blunt-tipped instrument or fan retractor parallel to the great vessels to retract the bowel medially and expose the underlying renal hilum (Fig. 6–11).

During a right-sided radical nephrectomy, retract the liver to improve visualization of the renal hilum by passing a 3- or 5-mm instrument through a fourth trocar placed in the midline or in the midclavicular line. Pass the instrument under the edge of the liver for elevation and retraction. The instrument can be held by an assistant, secured to the drape with a towel clamp, or clamped to the lateral side wall with a locking grasper (Fig. 6–12).

Completing Radical Nephrectomy

After securing the renal hilum, complete dissection of the upper pole. Determine the superior margin by whether or not the ipsilateral adrenal gland is to be removed along with the specimen. Regardless, the liver often needs to be elevated superomedially to allow right upper pole dissection, and, for a left-sided procedure, splenorenal attachments should be divided to allow the spleen to fall away superomedially. The liver is best elevated with either a blunt-tipped instrument or fan retractor inserted through the upper midline trocar. If the adrenal gland is not to be removed, the atraumatic forceps and electrocautery scissors (or US scalpel) are used to incise the overlying peritoneum, enter Gerota's fascia, and separate the adrenal gland from the upper pole of the kidney (Fig. 6–13*A*). Of note, for a left-sided procedure, take care to preserve the adrenal vein during adrenal-sparing nephrectomy (Fig. 6–14*A*).

If the adrenal gland is to be removed with the specimen, immediate control and division of the adrenal vein are imperative. For a right-sided procedure, dissection cephalad along the vena cava identifies the adrenal vein. Once it is divided, the superior, medial, and posterior attachments of the adrenal gland are mobilized (see Fig. 6–13*B*). Adequate exposure for this dissection usually requires elevation and retraction of the liver. For a left-sided procedure, the adrenal vein is secured near the renal vein and cut between two pairs of clips. The adrenal gland is then dissected away from the aorta with electrocautery scissors (see Fig. 6–14*B*). Any significant vessels encountered are clipped and divided.

The dissection is completed across the superior and posterior margins of the adrenal gland. Be aware of the splenic hilar vessels and the tail of the pancreas during this maneuver on the left. As an alternative to meticulous dissection with the electrocautery scissors around the upper pole and adrenal bed, multiple firings of the endovascular stapler may be employed. This reduces operative time but obviously will substantially increase the cost of disposable instrumentation.

Finally, divide the lateral and posterior attachments to the side wall and psoas muscle by pulling the kidney medially and using electrocautery and endoscopic scissors. Much of the dissection can be accomplished by using the tip of the irrigator-aspirator as a blunt dissecting instrument (Fig. 6–15). At this point, the ureter may be divided and used as a handle to adequately elevate the specimen and assist with the lateral and posterior dissection. During a right-sided radical nephrectomy, the segment of peritoneum overlying the anterolateral aspects of Gerota's fascia is included with the specimen.

Text continued on page 82

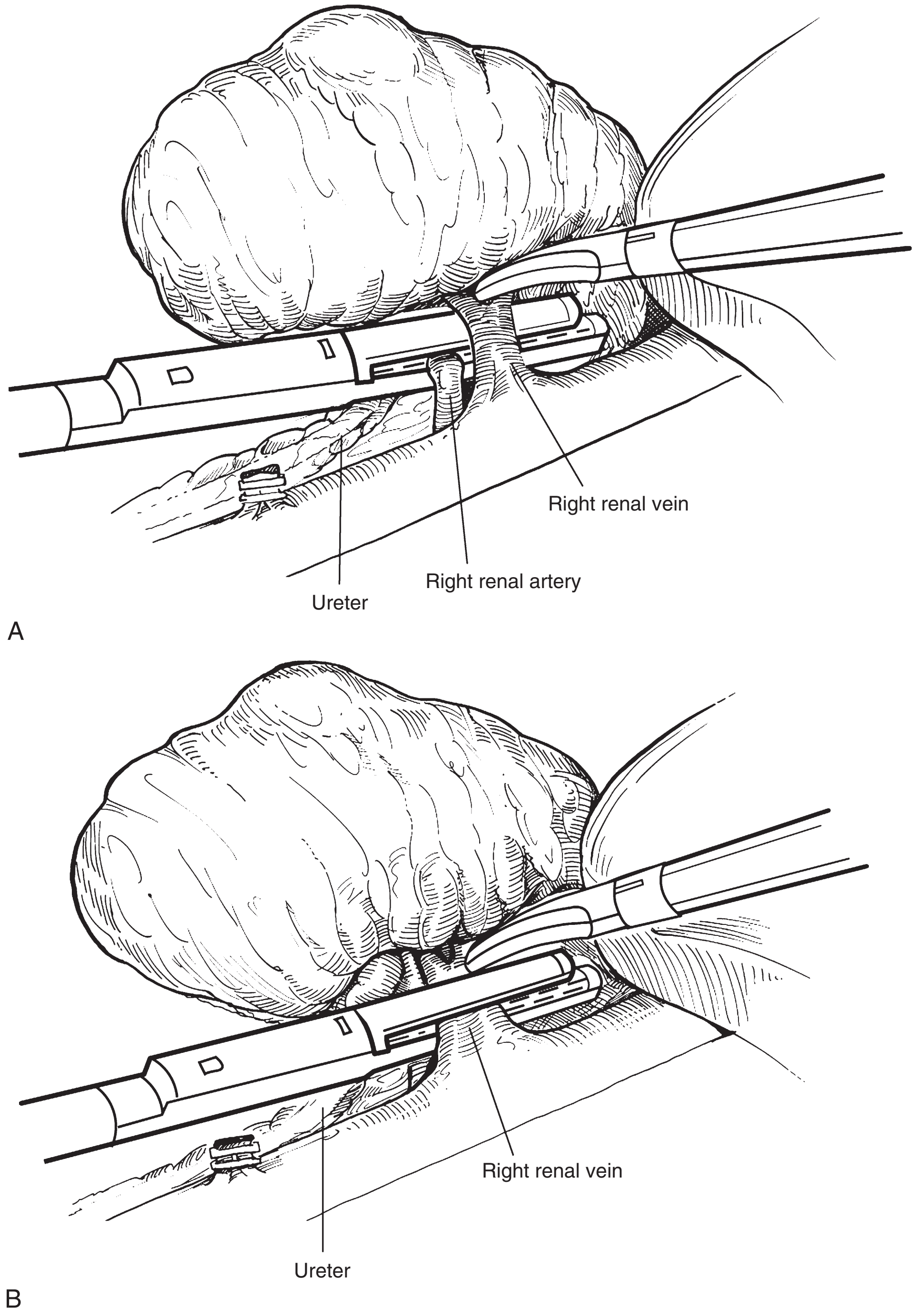


FIGURE 6–10. *A,* The renal artery is divided with an endovascular stapler. Note that the specimen is elevated with graspers to improve hilar exposure during placement of the stapler. *B,* The renal vein is also divided with an endovascular stapler after the arteries have been secured.

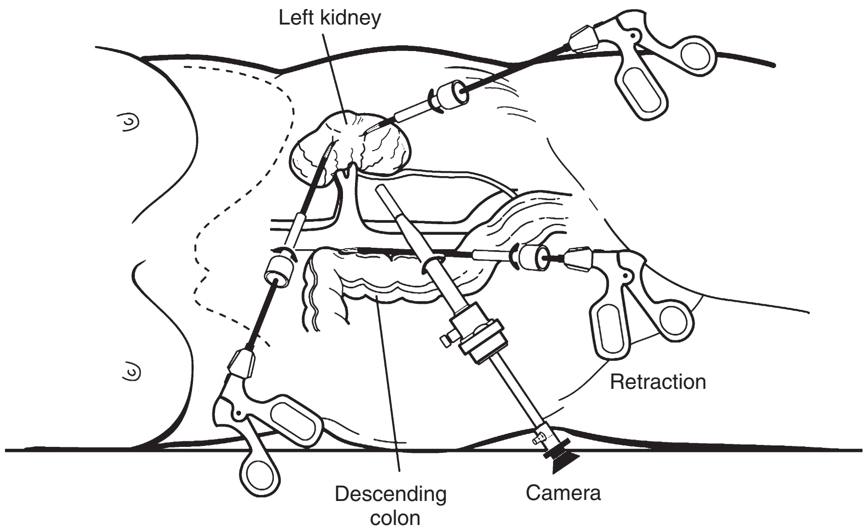


FIGURE 6–11. Schematic representation of trocar alignment during left nephrectomy. In particular, note that the additional suprapubic port facilitates hilar dissection by allowing the positioning of a blunt-tipped instrument for medial retraction of the bowel.

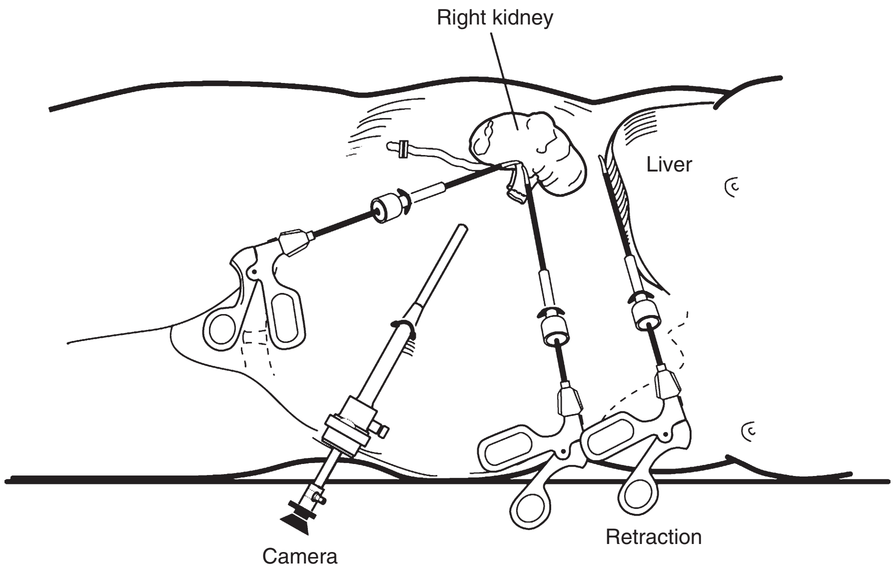


FIGURE 6–12. Schematic representation of trocar alignment during right nephrectomy. In particular, note that the additional subcostal port placed in either the midclavicular line or the midline facilitates dissection of the specimen by allowing the positioning of a blunt-tipped instrument for elevation and retraction of the liver.

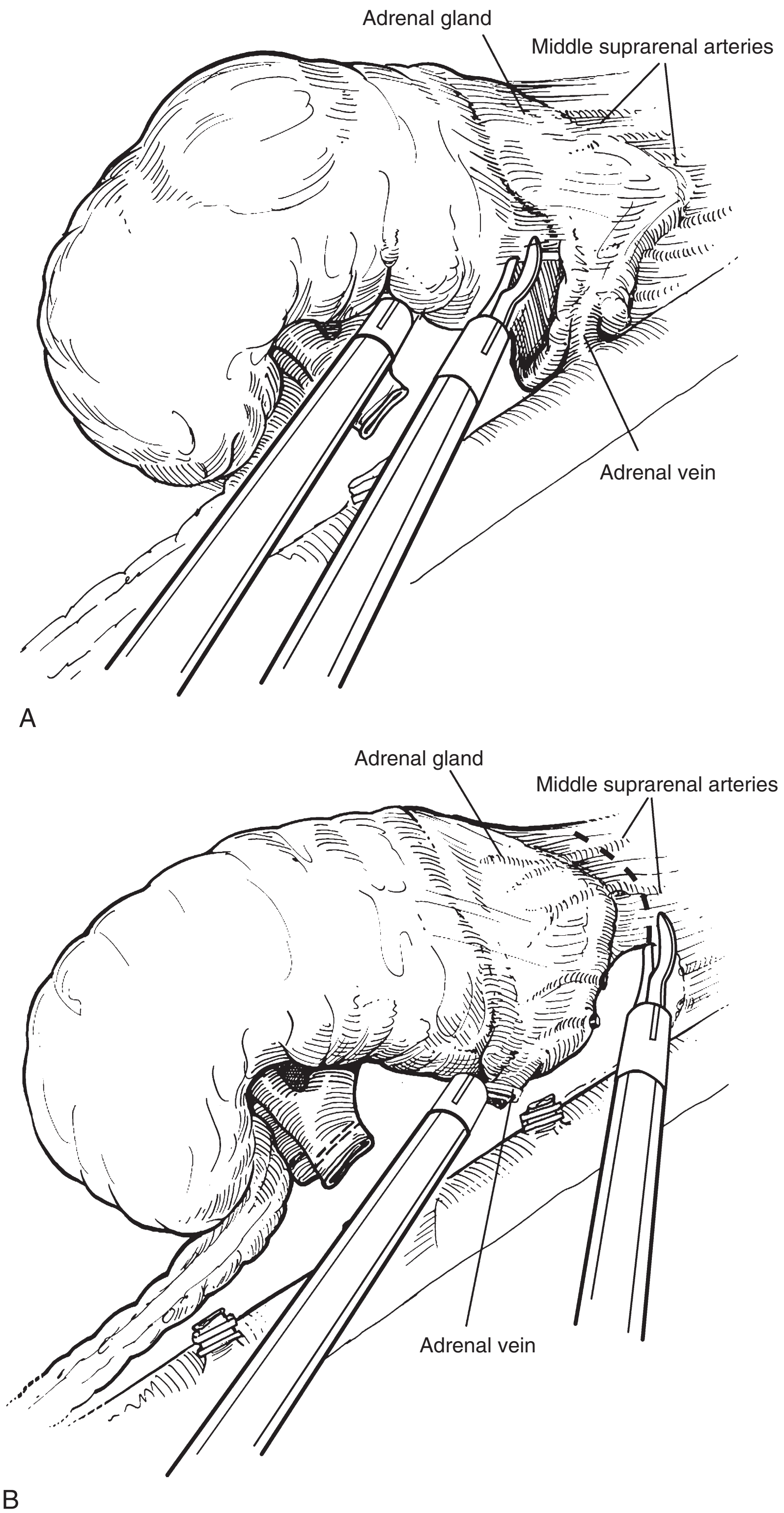
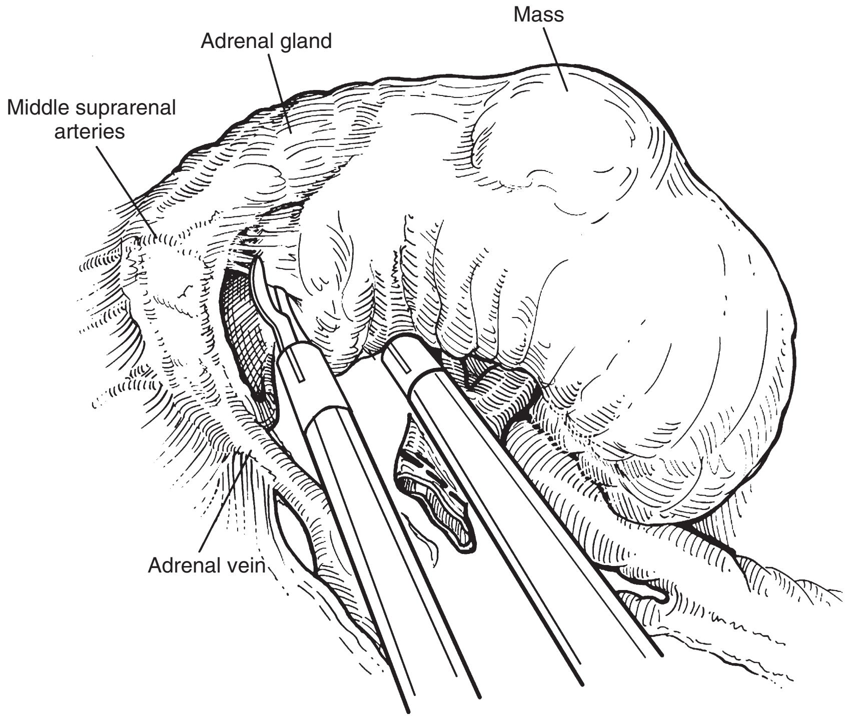


FIGURE 6–13. *A,* Adrenal-sparing right radical nephrectomy. Sharp cautery dissection is employed to release all adrenocolic and adrenorenal attachments. Inferior retraction of the specimen facilitates exposure of this surgical plane. *B,* If the adrenal gland is to be included with right radical nephrectomy, the adrenal vein must be identified early in the procedure. This vein should then be divided either between clips or with an endovascular stapler to prevent avulsion injury at the vein's insertion on the vena cava. Superior attachments, including small adrenal arteries, are divided with the electrocautery and between clips when necessary.



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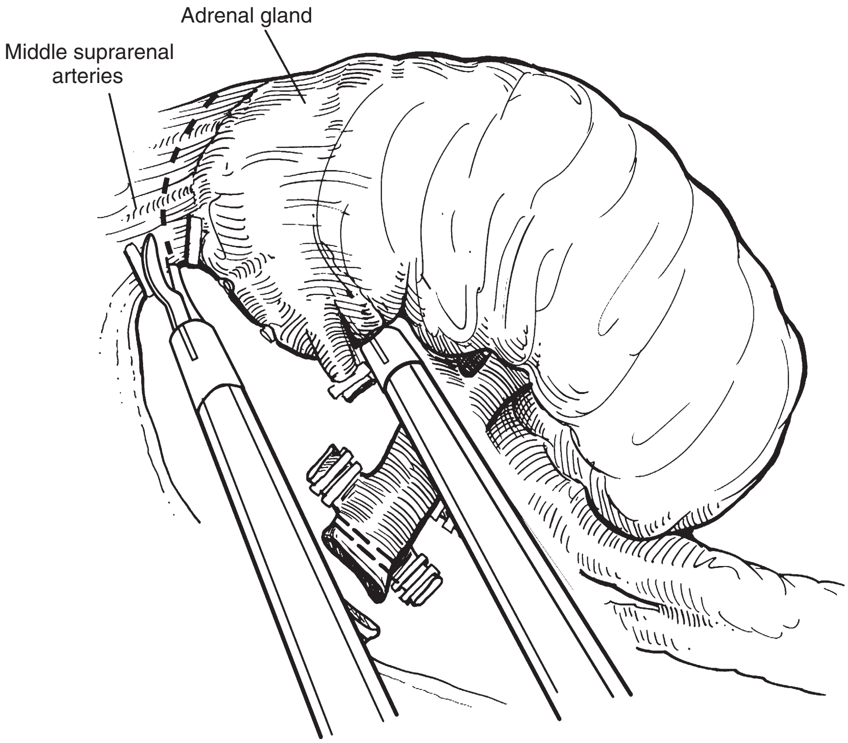


B

FIGURE 6–14. *A,* Adrenal-sparing left radical nephrectomy. Sharp dissection and electrocautery are employed to release all attachments between the adrenal gland and the kidney, colon, and spleen. Inferior retraction of the specimen facilitates exposure of this surgical plane. Note that the renal vein was divided before its confluence with the left adrenal vein. *B,* If the adrenal gland is to be included with left radical nephrectomy, the adrenal vein should be identified and divided between clips. Note that the renal vein was divided after its confluence with the left adrenal vein. Superior attachments, including small adrenal arteries, are divided with the electrocautery and between clips when necessary.

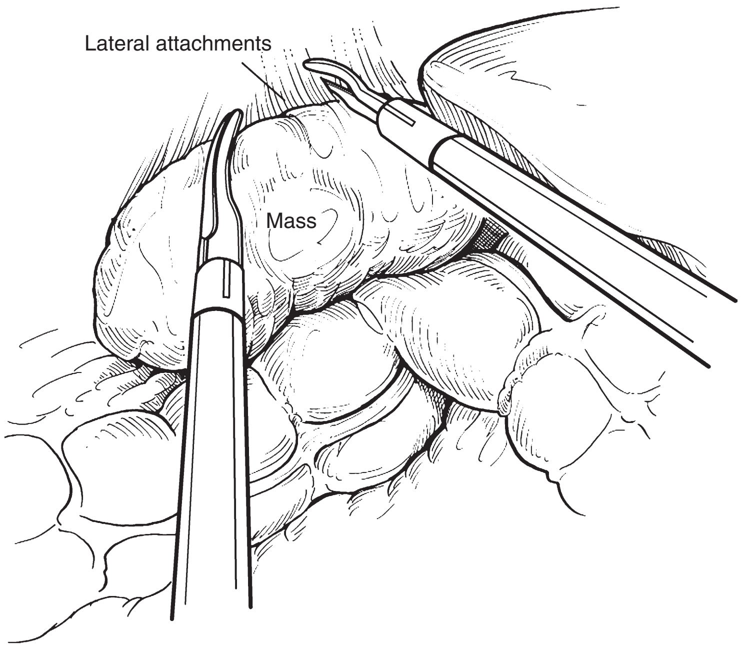


FIGURE 6–15. The lateral attachments to the side wall and the posterior attachments to the psoas muscle are divided. The kidney is pulled medially, and electrocautery, scissors, or blunt dissection with the tip of the irrigator-aspirator is used to free the kidney.

Dividing the Ureter

If not already divided during upper and lateral pole dissection, now divide the ureter between clips. Do not divide the ureter before securing the renal hilum because the ureter gives stability to the specimen and provides anatomic orientation during hilar dissection.

Observing for Hemostasis

After the specimen is completely freed in the abdominal cavity, use graspers to move the kidney from the renal fossa by placing it above the liver or spleen. Lower the pneumoperitoneum to a pressure of 5 mm Hg or less for at least 5 minutes. Closely observe the entire operative field and especially the renal hilum to find any vessels that may have been occluded by higher pressures during the procedure. Address any unrecognized bleeding or injury at this time.

Entrapping the Specimen

Perform intra-abdominal entrapment of the excised specimen to facilitate removal. If the specimen is to be removed intact through an incision, use an EndoCatch retrieval device and bag (U.S. Surgical, Norwalk, CT) or similar device. The EndoCatch instrument consists of a plastic sac attached to a self-opening, flexible metal ring. The primary advantage of a self-opening bag is that the specimen can be easily manipulated into the opening of the bag with a single grasper. The EndoCatch comes in two sizes: 10-mm with a 6-inch-deep bag and 15-mm with a 9-inch-deep bag. The 15-mm device is usually needed for radical nephrectomy specimens and is passed directly through the skin after the 10/12-mm trocar is removed.

Before removal of the trocar, insertion of the EndoCatch device, and entrapment of the specimen, preplace fascia-closing sutures in the 10/12-mm ports under direct vision using a fascial closure device. If a radially dilating trocar device was used for port placement, fascial port closure may be unnecessary and this step can be omitted.

To entrap the specimen, position the laparoscope in the lower quadrant (10/12-mm) port and replace the umbilical trocar with the EndoCatch device. To place the 15-mm bag, remove the trocar and pass the device directly through the incision. Then lift the kidney with a 5-mm grasper, place it above the liver or spleen, open the EndoCatch bag, and carefully drop the specimen into the bag (Fig. 6–16). First, pull the drawstring to close the bag and separate it from the wire deployment ring. Next, close the ring under direct vision to ensure that trocars or vital structures are not inadvertently included in the device.

Once the specimen is in the EndoCatch bag, withdraw the EndoCatch device and bag through the trocar site (Fig. 6–17*A*). Cut the suture and release the device from the bag (see Fig. 6–17*B*). Make A 4- to 6-cm skin incision to extract the bag and specimen, and divide the fascia with electrocautery. During this maneuver, protect the specimen and bag with the index finger positioned alongside the specimen through the trocar site (see Fig. 6–17*C*).

Alternatively, remove the kidney through a Pfannenstiel incision. First place the EndoCatch device and bag through an incision a few centimeters above the pubis. Remove the bag and specimen through the Pfannenstiel incision (Fig. 6–18).

Most surgeons prefer intact extraction of radical nephrectomy specimens, but morcellation is an option. If the specimen is to be morcellated, the EndoCatch bag will *not* suffice because the bag's material will easily perforate during morcellation. The LapSac entrapment bag (Cook Urological, Inc., Spencer, IN) is recommended. It is fabricated from a double layer of plastic and nondistensible nylon and has been shown to be impermeable to bacteria and tumor cells.[4] This bag is not attached to any ring or instrument. Entrap the drawstring within the bag while wrapping the bag around the shaft of the laparoscopic forceps. Then introduce the bag into the abdomen through the lower quadrant port site. Remove the trocar and pass the LapSac

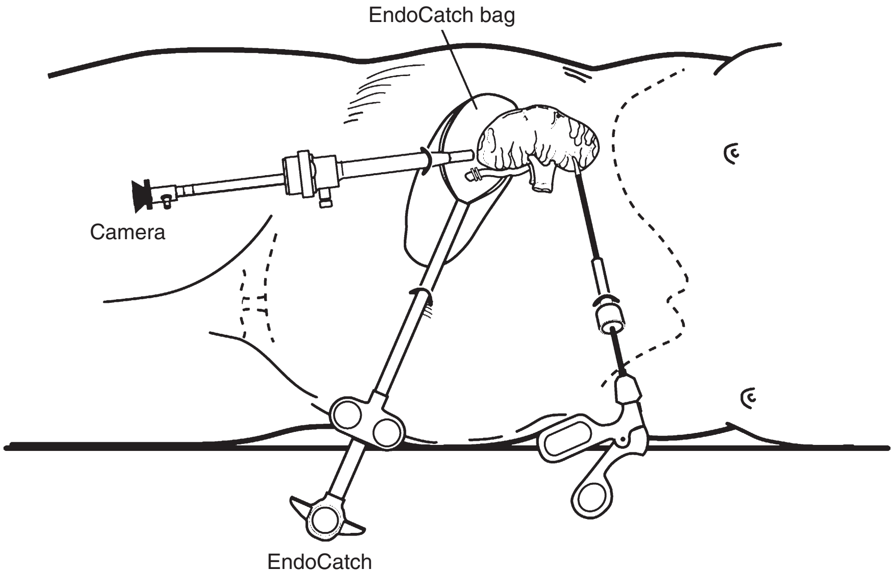


FIGURE 6–16. Placement of the specimen into an opened EndoCatch device placed through umbilical trocar site. Note that the camera is positioned in the lateral port and the specimen is maneuvered with the upper midline trocar. The umbilical trocar is removed to accommodate the 15-mm EndoCatch device.

directly through the abdominal wall (Fig. 6–19). Place the kidney above the spleen or liver before introducing the bag into the abdomen. Once the bag is in the abdominal cavity, replace the trocar by means of a blunt obturator.

After introducing the LapSac, unfurl it within the abdomen and position it flat with its bottom in the pelvis. This positioning is critical to facilitate entrapment of the specimen. Hold the bag open below the corresponding liver or spleen edge so that the specimen can be advanced slowly over the spleen or liver edge and into the open LapSac. Placing the specimen within the LapSac is often challenging, especially when there are only two ports through which to work. An additional 3- or 5-mm lateral trocar and grasper may be helpful in keeping the sac open (Fig. 6–20). Use only atraumatic graspers to manipulate the bag in order to prevent perforation. Once the specimen is inside the LapSac, grasp the drawstring, tighten it, and withdraw it into the 10-mm umbilical port, which pulls the neck of the bag into the port as well. Use of the LapSac can be facilitated by looping a hydrophilic wire through the holes in the mouth of the sac before placement in the abdomen. The loop of wire helps to hold the LapSac in the open position for easier organ entrapment (Fig. 6–21).

Removing the Specimen

If the specimen is removed intact (the preferred technique) within the EndoCatch bag, make a 4- to 6-cm periumbilical incision that incorporates the umbilical port incision or Pfannenstiel incision (see Fig. 6–17*C*). To aid in cosmesis, hide at least 2 cm of the incision within the umbilical fold. It is critical to take care to avoid tearing or perforating the EndoCatch bag during this step. Open the fascia and deliver the specimen.

If the specimen is to be morcellated, pull the LapSac drawstring through the umbilical port, drawing the neck of the sac into the sheath. Then remove the sheath so that the neck of the sac rests on the abdomen. Preserve the pneumoperitoneum throughout the morcellation process so that the intra-abdominal portion of the bag can be monitored laparoscopically for possible perforation. Tightly pull the sac against the abdomen, and begin morcellation. Place surgical towels around the sac, and cover the entire surgical field to prevent contamination of the port site with any spillage of the morcellated specimen.

Morcellation can be performed either manually or with a high-speed electrical morcellator. If the electrical tissue morcellator is available, connect it to wall suction with the foot pedal. Electrical morcellators generally consist of a tissue-trapping chamber and a 10-mm barrel that contains a recessed blade. Morcellators must be used with great care. With the neck of the sac pulled tightly upward, introduce the barrel into the sac and move it back and forth through the renal tissue (Fig. 6–22*A*). When specimen contact is made, turn on the suction and activate the recessed blade with the foot pedal. Every few minutes, empty the aspirated renal fragments from the trapping chamber to ensure that maximum suction is maintained. To prevent aspiration and perforation of the sac, keep in mind the following points:

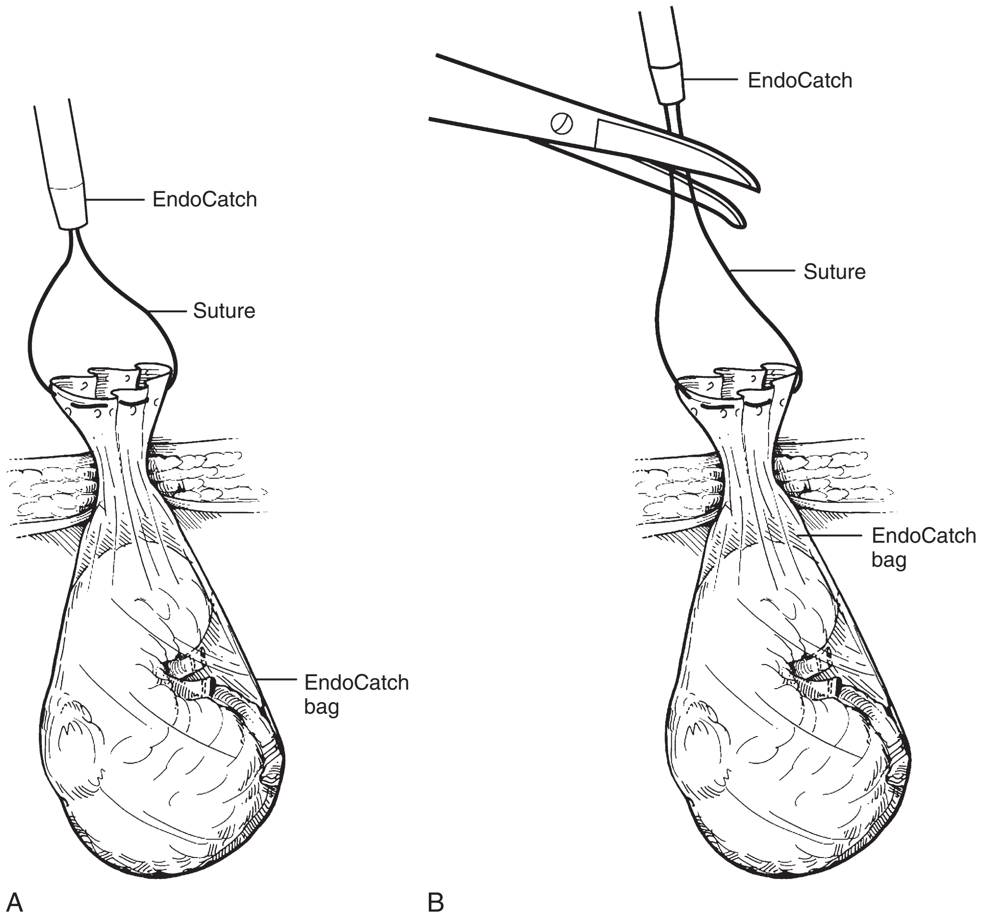
- Keep constant upward traction on the sac.
- Maintain continuous laparoscopic visualization of the sac.
- Use short, controlled, back-and-forth motions of the morcellator.

Alternating between electrical and manual morcellation is common and facilitates removal of fibrous fragments. The electrical morcellator alone is not effective with fibrotic kidneys.

For manual morcellation, introduce a Kelley clamp or ring forceps into the sac to fragment the kidney (see Fig. 6–22*B*). Systematically pull pieces of renal tissue from the sac until the residual mass is small enough to be withdrawn through the port incision. Then withdraw the bag with the residual specimen and reintroduce a 10-mm trocar to preserve the pneumoperitoneum (see Fig. 6–22*C*).

Closing

If the specimen is removed intact, inspect the bowel and retroperitoneum for potential bleeding or injury at both 5 and 15 mm Hg pressure before removing the specimen (see earlier). Place fascial closure sutures as necessary at the 10/12-mm trocar sites and sequentially remove the ports under



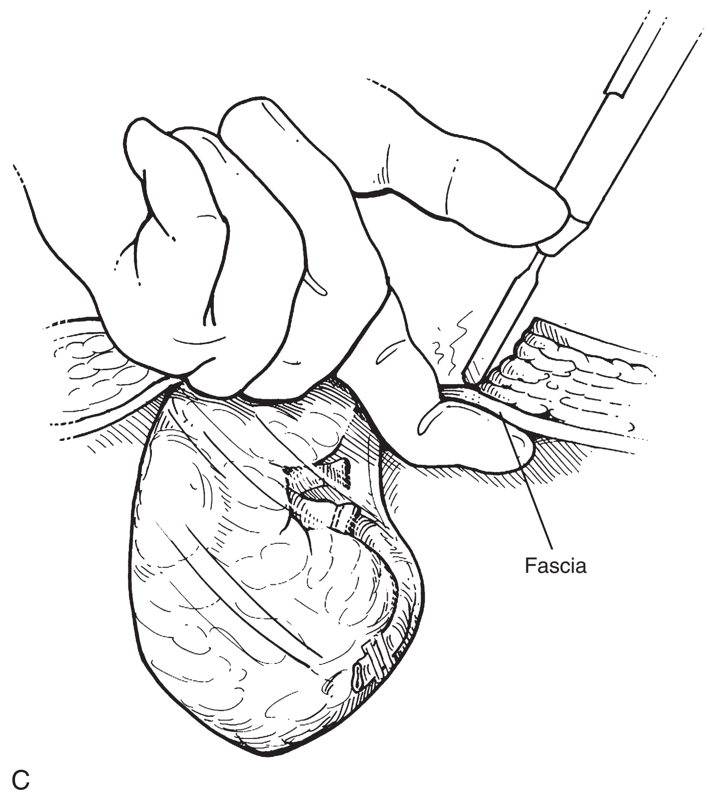


FIGURE 6–17. Removal of an intact specimen. *A,* Once the specimen is within the EndoCatch bag, the bag is cinched closed and the device and bag are withdrawn through the trocar site. The top of the bag should be above the skin. *B,* The suture is cut to release the device from the bag. *C,* A 4- to 6-cm skin incision is made to extract the bag and specimen. The fascia is divided with electrocautery. The bag and specimen are protected during this maneuver by the surgeon's index finger positioned alongside them through the trocar site.

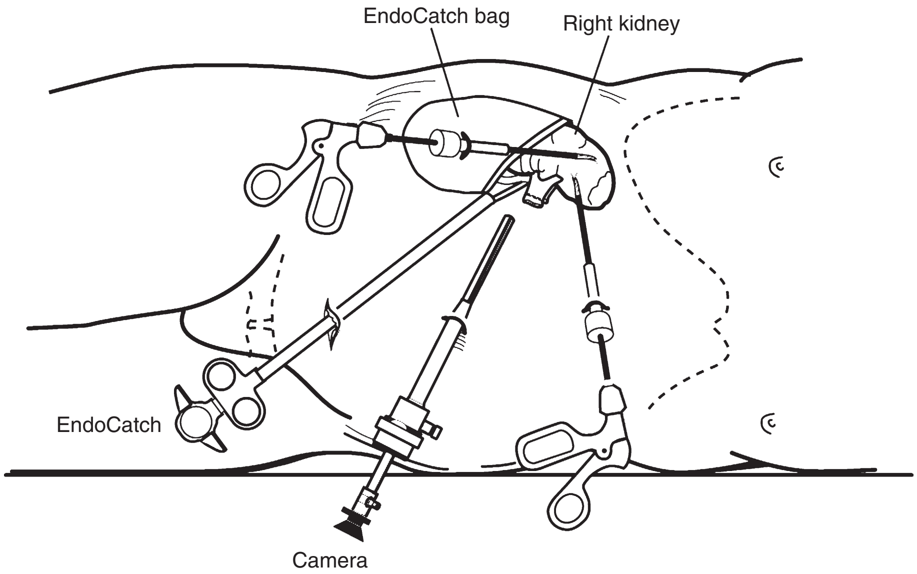


FIGURE 6–18. Alternative extraction of an intact specimen through a Pfannenstiel incision. A suprapubic 10-mm midline port is placed and then is replaced with the EndoCatch device. The specimen is secured within the bag and extracted through a 4- to 6-cm Pfannenstiel incision.

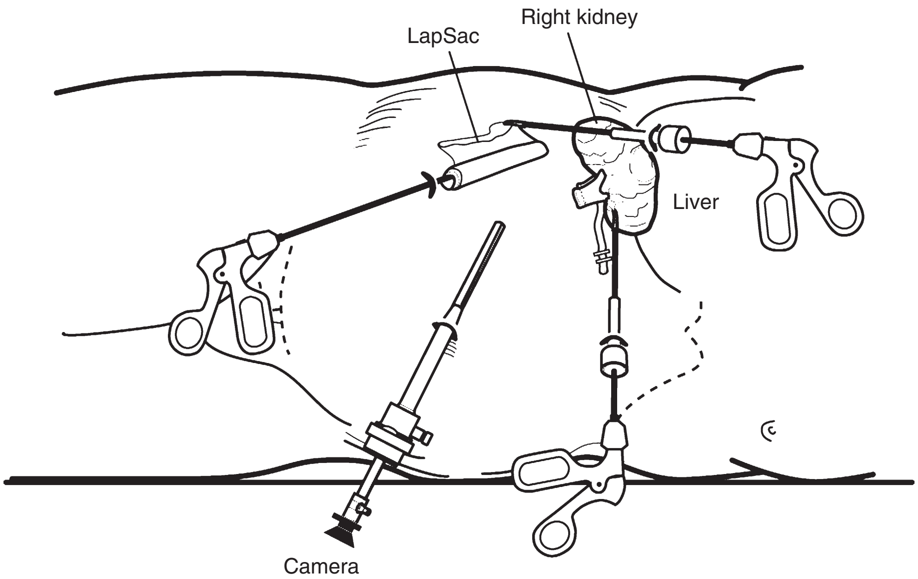


FIGURE 6–19. Introduction of a LapSac entrapment bag through the lateral 10-mm trocar site. Note that the bag is rolled around an atraumatic grasper and then introduced through the trocar site. The actual port is removed during this maneuver because the bag would get caught in the trocar, disrupting the seal.

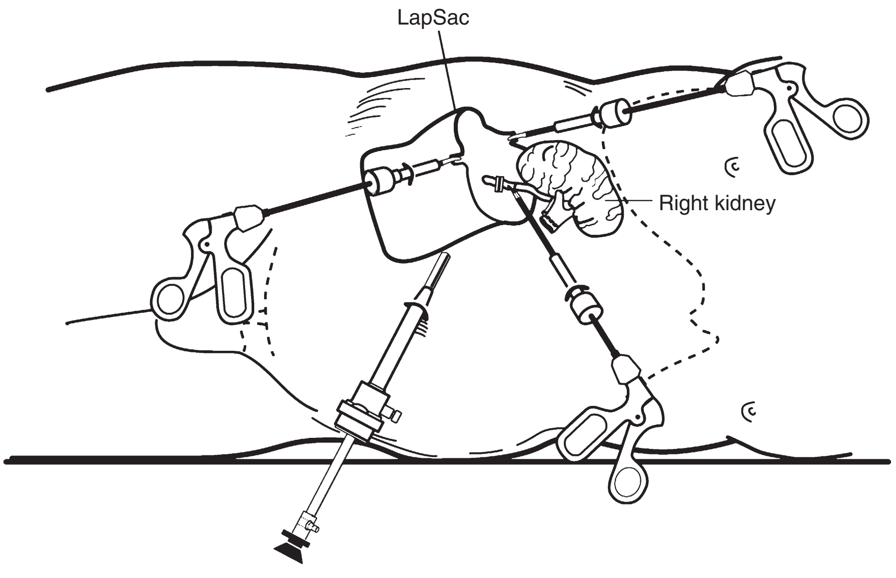


FIGURE 6–20. After the LapSac entrapment bag is released within the abdomen, the 10-mm port is replaced, and the sac is unfurled. For placement of the specimen within the bag, a lateral 5- or 3-mm port usually must be placed to assist with holding the bag open.

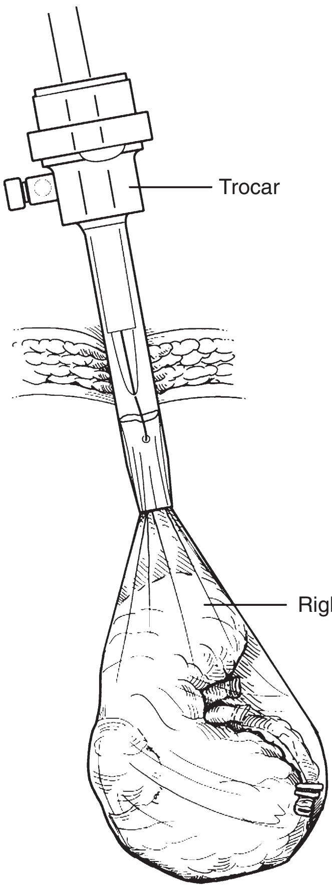


FIGURE 6–21. Once the specimen is within the LapSac entrapment bag, the bag is cinched closed and drawn through the 10-mm lateral trocar.

laparoscopic visualization. Then remove the specimen through the extraction incision. Close the incision in a standard fashion after venting the pneumoperitoneum completely. If the size of the renal specimen precludes good visualization of the dissection field or if there is high concern for bleeding or injury, leave the lower quadrant and upper trocars in place and reinsufflate the abdomen after completing the extraction site fascial closure. Then tie the trocar fascial sutures, and close the skin at all port sites in standard fashion.

If morcellation is used, reintroduce the laparoscope into the abdomen to observe for potential bleeding or injury, including in the area at which the morcellation was performed. Inspection should take place at both 5 and 15 mm Hg pressure. Then remove the trocars and close the port sites sequentially.

POSTOPERATIVE MANAGEMENT

At the conclusion of the procedure, remove the orogastric tube. The patient starts on a clear liquid diet following surgery and is advanced to a regular diet as tolerated. The urethral catheter is removed and the patient ambulates on the first postoperative morning. Control pain with a patient-controlled analgesia device administering narcotics. By the second postoperative day, oral analgesics are generally sufficient. Postoperative antibiotics generally are not necessary. Depending on the age, physical status, and comorbid conditions, the patient is usually discharged on the first or second postoperative day.

COMPLICATIONS

The complications occurring during or after laparoscopic radical nephrectomy have been well described. In a large multicenter study examining only laparoscopic radical nephrectomy complications, Cadeddu and associates[5] reported the combined major and minor complication rate to be 9.6%. Another series of 100 patients undergoing laparoscopic radical nephrectomy demonstrated a combined complication rate of 14%: 3% major and 11% minor complications.[6]

Complications can occur during various steps in the operative procedure. Potential access-related complications include trocar site bowel herniation, abdominal wall hematoma, and bowel or solid organ injury. Intraoperatively, liver, spleen, bowel, and vascular injuries can occur. The surgical team must be prepared for emergent conversion to an open procedure secondary to such injuries. A general laparotomy set with vascular clamps must be readily available for each procedure.

The potential postoperative complications are similar to those encountered after open radical nephrectomies. They include urinary tract infection, prolonged ileus, pulmonary embolus, pneumonia, brachial nerve palsy, atrial fibrillation, and congestive heart failure.

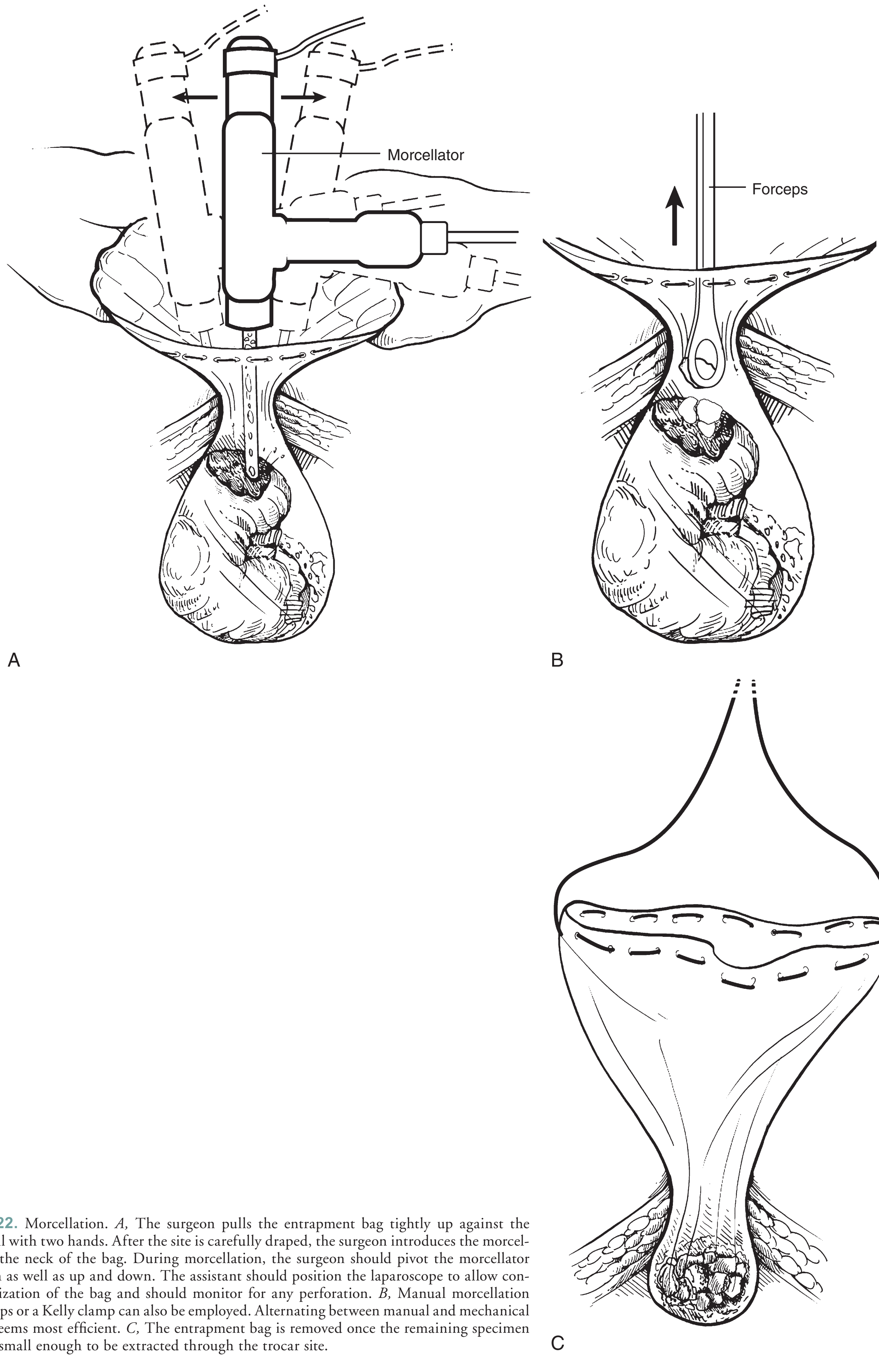


FIGURE 6–22. Morcellation. *A,* The surgeon pulls the entrapment bag tightly up against the abdominal wall with two hands. After the site is carefully draped, the surgeon introduces the morcellator through the neck of the bag. During morcellation, the surgeon should pivot the morcellator back and forth as well as up and down. The assistant should position the laparoscope to allow continuous visualization of the bag and should monitor for any perforation. *B,* Manual morcellation with ring forceps or a Kelly clamp can also be employed. Alternating between manual and mechanical morcellation seems most efficient. *C,* The entrapment bag is removed once the remaining specimen fragments are small enough to be extracted through the trocar site.

Tips and Tricks

- Be sure that the patient is positioned properly and well secured before beginning procedure.
- Use rotation of the surgical table and gravity to your advantage.
- Insert additional 5-mm ports as needed throughout the duration of the surgery with little effect on cosmesis or postoperative pain.
- Always have the tips of the scissors visible during use of electrocautery to avoid bowel injury.
- The ureter is useful for retraction during dissection of the hilum and should not be divided until the renal vessels have been divided.
- Always ensure that the stapler is completely across the vessel being divided and always be prepared for equipment malfunction.
- Upper pole dissection can be tedious but must be done with care to avoid bleeding complications and need for conversion.
- Perform meticulous closure of the extraction site fascial incision to prevent postoperative hernias.

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CHAPTER 7

Hand-Assisted Laparoscopic Radical Nephrectomy

George K. Chow

Hand-assisted laparoscopic radical nephrectomy (HALRN) was first described by Tierney and colleagues in 1994.[1] Although no actual hand port device was used, the kidney was extracted manually through an incision. The first reported clinical usage of a dedicated hand-assistance device for laparoscopic nephrectomy was performed by Wolf and colleagues in 1997.[2]

INDICATIONS AND CONTRAINDICATIONS

HALRN is appropriate whenever extirpative nephrectomy with intact extraction is indicated. If benign renal pathology is anticipated and morcellation will be used, pure laparoscopy would be preferable. For laparoscopists who prefer to morcellate malignant lesions, hand-assistance would also be moot.

The absolute contraindications to HALRN are renal vein or vena caval thrombus and bleeding diathesis. Another absolute contraindication is stage T4 disease with invasion into surrounding organs. The only exception to this is adrenal invasion; patients with adrenal invasion can be handled effectively by radical nephrectomy. If the patient has significant cardiopulmonary comorbidity, surgery may not be advisable. In this sense, the contraindications are not any different from those for pure laparoscopy.

Although tumor and specimen size is often considered a relative contraindication for pure laparoscopy, I find that this is less of a consideration with hand-assisted surgery. Manual assistance for retraction and dissection often facilitates removal of the large specimen.

Morbid obesity is a relative contraindication for laparoscopy. Usually, the obstacles presented by patient habitus can be overcome by modifying the hand port incision and trocar placement. I will typically place the hand port incision in a more cephalad paramedian position rather than at my typical infraumbilical site. These incisions tend to go through the rectus sheath, and one must be careful not to injure the epigastric vessels. An additional caveat is that both the anterior and posterior rectus sheaths need to be closed. Closing the anterior sheath alone is insufficient, and bowel herniation into the rectus sheath can occur.

PATIENT PREOPERATIVE EVALUATION AND PREPARATION

As with all radical nephrectomy patients, careful preoperative metastatic work-up is necessary. Order chest radiography or chest computed tomography (CT) to evaluate the chest for metastatic disease. Cross-sectional imaging of the abdomen with CT or magnetic resonance imaging (MRI) is useful to determine presence of metastatic disease or invasion of contiguous organs. The additional benefit of cross-sectional abdominal imaging is that vascular anomalies such as multiple vessels can be identified preoperatively, facilitating surgery. MRI is especially useful for ruling out tumor thrombus. If the patient has unexplained bone pain, order a bone scan. Furthermore, if the patient manifests neurologic signs or symptoms, order CT of the head.

Carefully evaluate the patient medically for anesthetic risk factors. Also, address any other conditions that may affect surgery such as cessation of anticoagulant therapy, subacute bacterial endocarditis prophylaxis, and potential drug allergies.

The day before surgery, instruct the patient to take a liquid dinner and stop eating and drinking after midnight. A light laxative preparation such as one bottle of magnesium citrate is usually sufficient to cleanse the bowels.

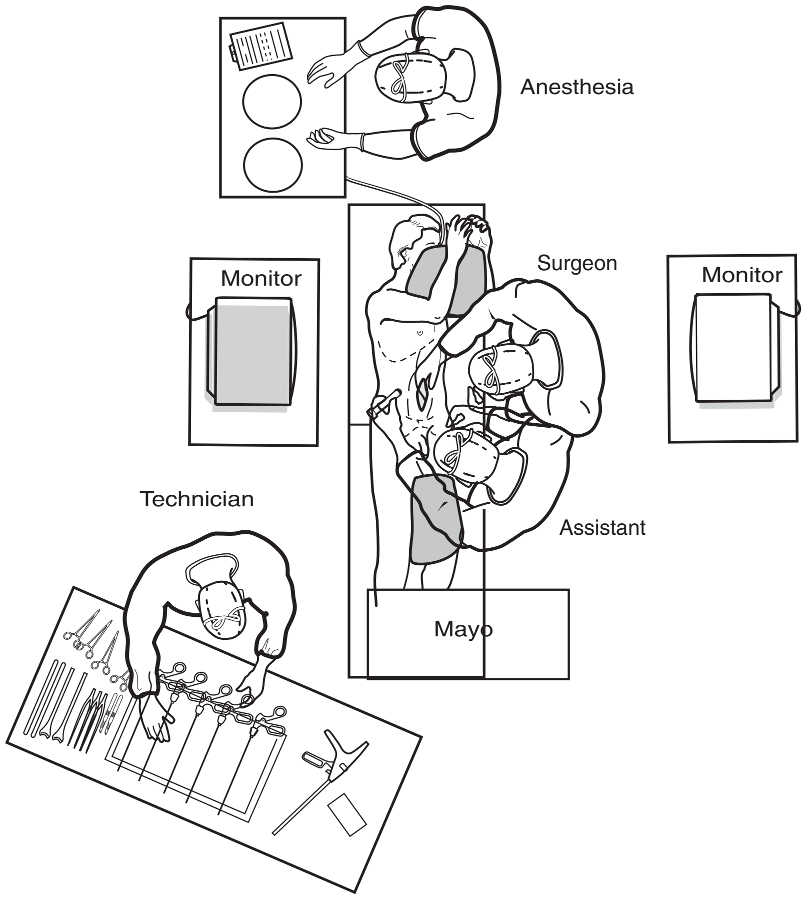
After induction of anesthesia, shave the patient and position him or her for surgery. Typically, I shave from nipples to just above the pubic hairline. Place a Foley urethral catheter to drain the bladder and use an orogastric tube to decompress the stomach. After positioning, prep and drape the patient for surgery.

OPERATING ROOM CONFIGURATION AND PATIENT POSITIONING

Anesthesia is located at the head of the table. The surgeon and assistant stand facing the ventral surface of the patient. The scrub nurse and scrub table are situated opposite the operating surgeon and assistant approximately at the level of the patient's waist. Situate a Mayo stand at the level of the patient's upper thigh, and place a monitor opposite the operating surgeon and assistant. Position the insufflation equipment and light source with the monitor facing the surgical team.

The actual position of the surgeon and assistant vary according to the side operated. As a rule of thumb, the assistant operates the camera standing to the left of the surgeon (Fig. 7–1).

The operating room is set up so that the surgeon and assistant can easily view the procedure on the monitors (see Fig. 7–1). Place the patient in the lateral decubitus or flank position. Place the arms on an arm board or in a sling at a 90-degree angle to the surgical table. Place the patient on a beanbag cushion leaned back slightly, about 30 degrees. Carefully pad all pressure points. Bend the bottom leg and place a pillow between the legs for padding. Place a roll in the axilla to prevent brachial plexus injury. Once positioned, suction the air from



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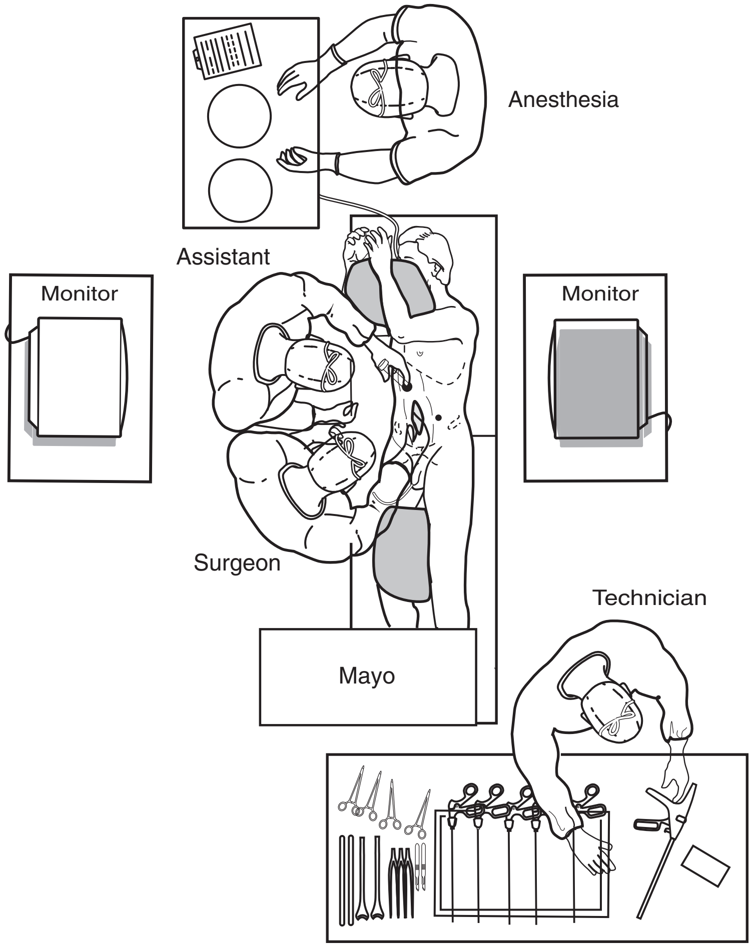


B

FIGURE 7–1. *A,* Setup for right-sided hand-assisted laparoscopic nephrectomy. The surgeon stands toward head of patient with left hand in hand-assist device, and the assistant operates camera from lateral trocar. *B,* Setup for left-sided hand-assisted laparoscopic nephrectomy. The surgeon stands toward the feet of patient, to maintain ergonomic positioning of hands. The left hand is once again placed within the patient's abdomen. The assistant stands to the right of the surgeon and operates the camera.

the beanbag to fix the patient in place. Use tape with cushioning pads to secure the patient to the surgical table. Perform a "tilt test" by tilting the patient from side to side to maximal excursion to ensure that the patient is properly secured (Fig. 7–2).

TROCAR PLACEMENT

Right Side

Initial placement of trocars is preceded by creation of the hand-assist incision. Typically, I place a vertical incision just underneath the umbilicus in the midline. In obese or exceptionally tall people, place this incision in a more lateral (preferably lateral to the rectus muscle) and cephalad position.

Use a three-trocar configuration. Place a 5-mm trocar for the endoscopic camera lateral to the right rectus muscle roughly at a position halfway between the costal margin and level of the umbilicus. Place a 10-mm trocar halfway between the umbilicus and the xiphoid process in the midline. Finally, place a 2-mm trocar for liver retraction just below the xiphoid process. Use a 2-mm locking grasping forceps to retract the liver by tenting the liver edge under the forceps as it grasps the triangular ligament of the liver (Fig. 7–3).

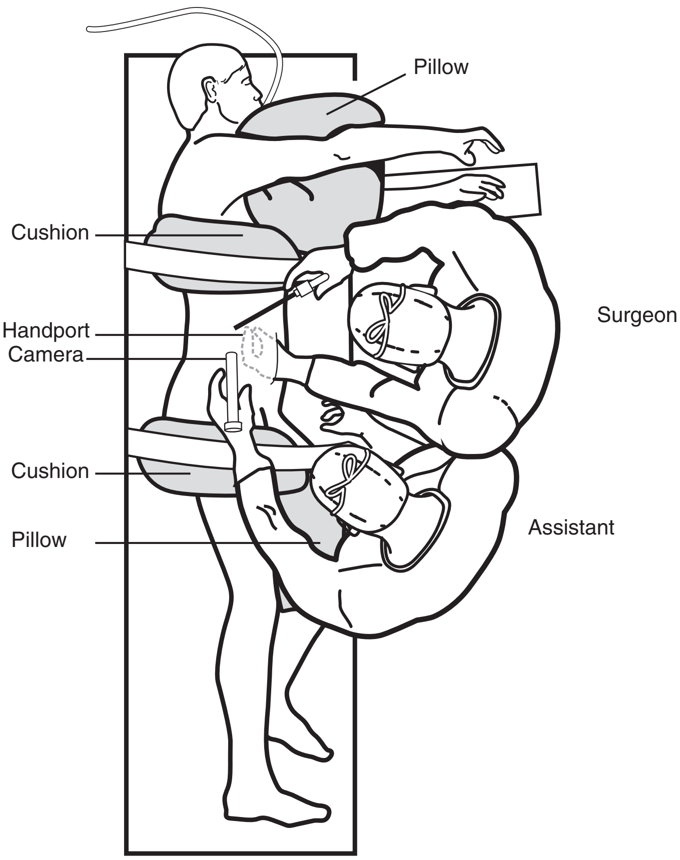


FIGURE 7–2. The patient is secured at the hips, shoulder, and chest.

Left Side

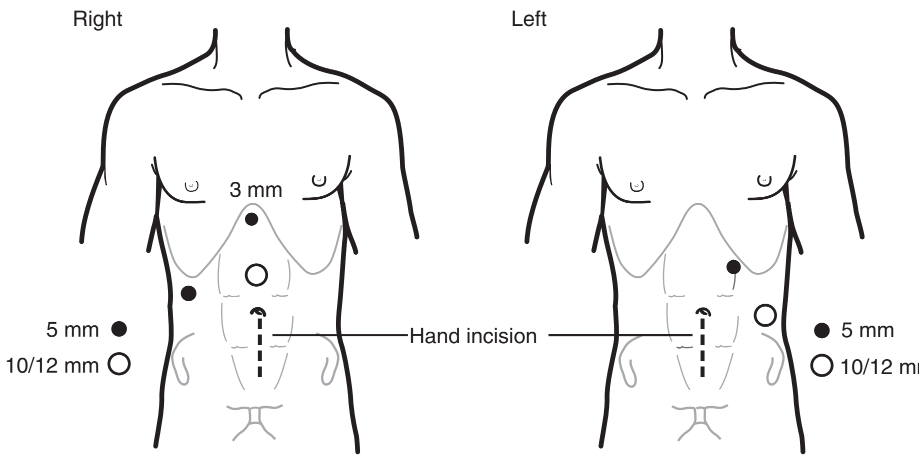
As with the right-sided surgery, the initial step is the creation of the hand-assistance/extraction incision. Use a two-trocar configuration. Place a 5-mm camera port at the junction of the lateral edge of the left rectus muscle and costal margin. Place a 10-mm instrument port lateral to the left rectus muscle roughly at the level of the umbilicus (see Fig. 7–3).

PROCEDURE

Left-sided HALRN starts with incision of the line of Toldt. Medially mobilize the left colon from the splenic flexure down. Identify the ureter and dissect it out in a fashion similar to the method described for right-sided surgery (see later). Perform the dissection toward the renal hilum. On both the right and left sides, use the thumb and finger to retract, spread, and dissect tissue planes (Fig. 7–4). Using the index finger, identify the artery and push it from under the renal vein. The finger can help guide placement of the endovascular stapler (Fig. 7–5). After dividing the artery, use the finger to dissect the vein, creating a window for placement of the endovascular stapler (see Fig. 7–5). When appropriate to spare the adrenal gland, the index finger can rapidly find and exploit the plane between the upper pole and the adrenal gland (Fig. 7– 6).

Right-sided HALRN starts with dissection of the hepatic flexure and incision of peritoneum at the line of Toldt. Medially mobilize the right colon to expose Gerota's fascia. Then medially mobilize the duodenum with sharp and blunt dissection (Kocher maneuver). The renal hilum is usually under the liver edge. Place a small grasper through a midline trocar under the

FIGURE 7–3. Trocar positioning. The hand incision is placed infraumbilically in both cases. Please note that a Pfannenstiel incision can replace the vertical incision in cases where maximum cosmesis is desired. A three-trocar technique is used for right side. The lateral 5-mm trocar is placed lateral to the rectus muscle roughly at the level of the umbilicus and serves as camera port. The working trocar (10/12 mm) is placed halfway between the xiphoid and the umbilicus. A 2- to 5-mm trocar is placed at the xiphoid to serve as a self-retaining liver retractor. For the left side, a two-trocar configuration is used. A 5-mm camera trocar is placed at the intersection of the lateral rectus muscle margin and the costal margin. A working trocar is placed lateral to the rectus muscle at the level of the umbilicus.



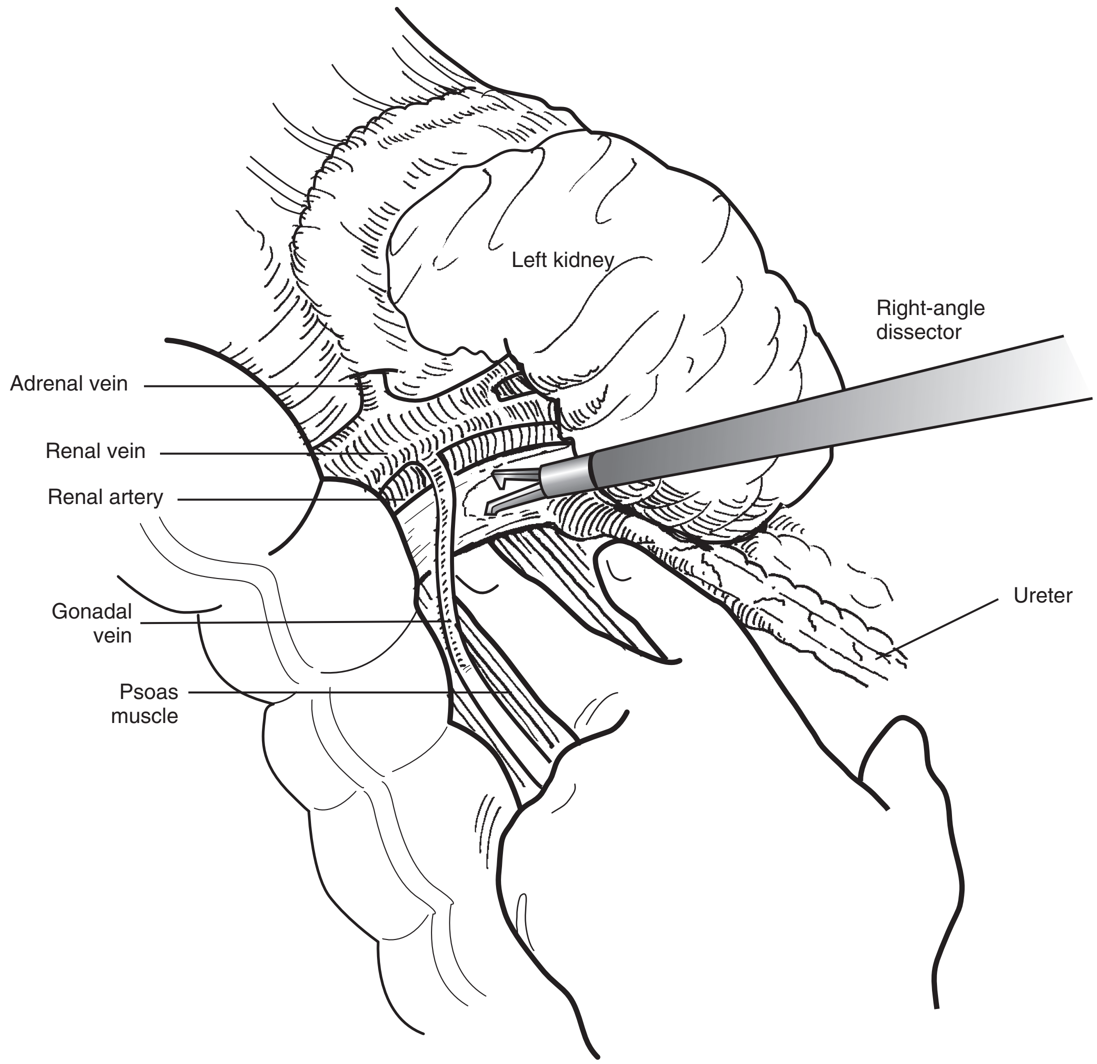


FIGURE 7–4. Left-sided dissection is performed after incising the peritoneum right on the lateral edge of the gonadal vein, and identifying and elevating the ureter. The plane between the ureter and gonadal is then dissected cephalad toward the renal hilum. The surgeon's hand serves to provide upward traction and blunt dissection during this dissection. In addition, finger palpation can assist in identification of structures.

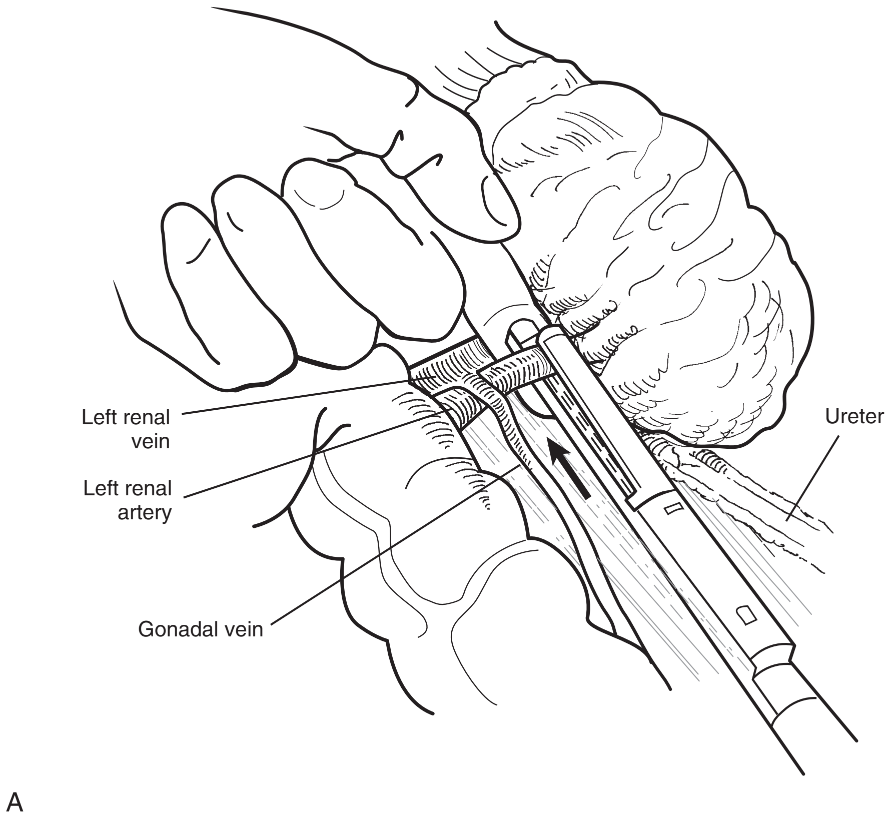
liver edge, and attach it to the side wall, elevating the liver and improving visualization of the renal vessels and vena cava (Fig. 7–7). If the right mesocolon is sufficiently mobilized, the gonadal vein is usually visible.

Enter Gerota's fascia just lateral to the lateral edge of the gonadal vein, and manually palpate and dissect to identify the ureter. Then manually develop the posterior plane between the psoas fascia and Gerota's fascia, and elevate the ureter to expose the axis of dissection between the ureter and gonadal vein. The dissection proceeds cephalad with blunt dissection and touch cautery until the renal hilum is identified. Use a laparoscopic right-angle clamp to dissect the adventitia off the artery and vein. Identify the artery with the finger. Once the artery is adequately dissected free, use the laparoscopic stapler to divide the artery. Next, once the vein is dissected free, ligate the vein in a similar fashion. At this point, decide whether or not to preserve the adrenal. If there is adequate separation of the adrenal from the tumor and preoperative CT scan shows no metastases, the adrenal gland can be spared. Spare the adrenal gland by using the right-angle clamp to slowly dissect the adrenal away from the kidney. Next, divide lateral and superior attachments with cautery scissors or hook. Blunt dissection with the hand can greatly facilitate this portion of the case. With the kidney freed, ligate and divide the ureter with a clip. Place the specimen in a specimen extraction sac and remove. Although some surgeons may elect to forgo the extraction sac, I believe that using the sac facilitates extraction of larger specimens through small incisions.

POSTOPERATIVE MANAGEMENT

After surgery, remove the patient's orogastric tube, and send the patient to the postanesthesia care unit. The patient begins ambulating and starts a clear liquid diet the next morning. Standard blood tests including creatinine and hemoglobin/hematocrit are checked the next morning.

When the patient passes gas, regular diet is resumed, and the patient can be discharged home. In my experience, most patients leave on postoperative day 2.



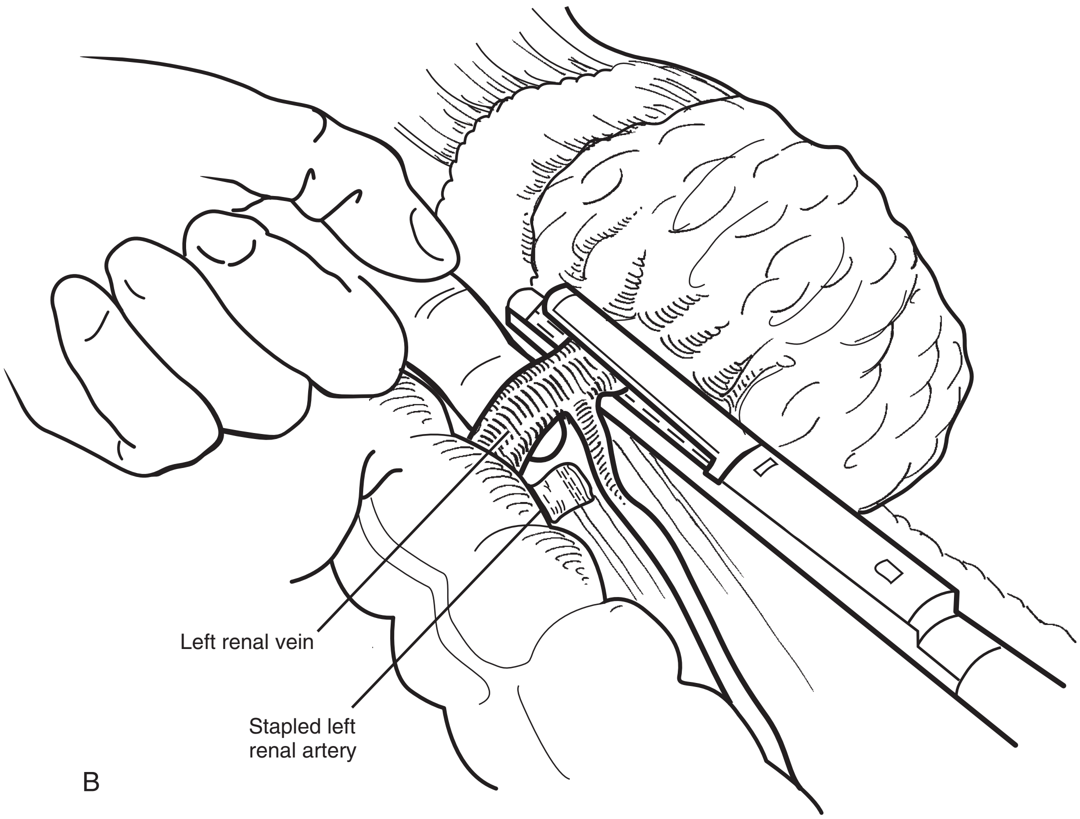


FIGURE 7–5. *A,* Division of left renal artery. Although it is not always possible, a finger can sometimes be placed completely around the renal artery and assist placement of the vascular stapler. Another technique that can be used if there is incomplete visualization of the artery is to first clip the artery (preferably with a locking clip) and then staple the vein. One can then staple the artery without the vein blocking the view. *B,* Division of left renal vein.

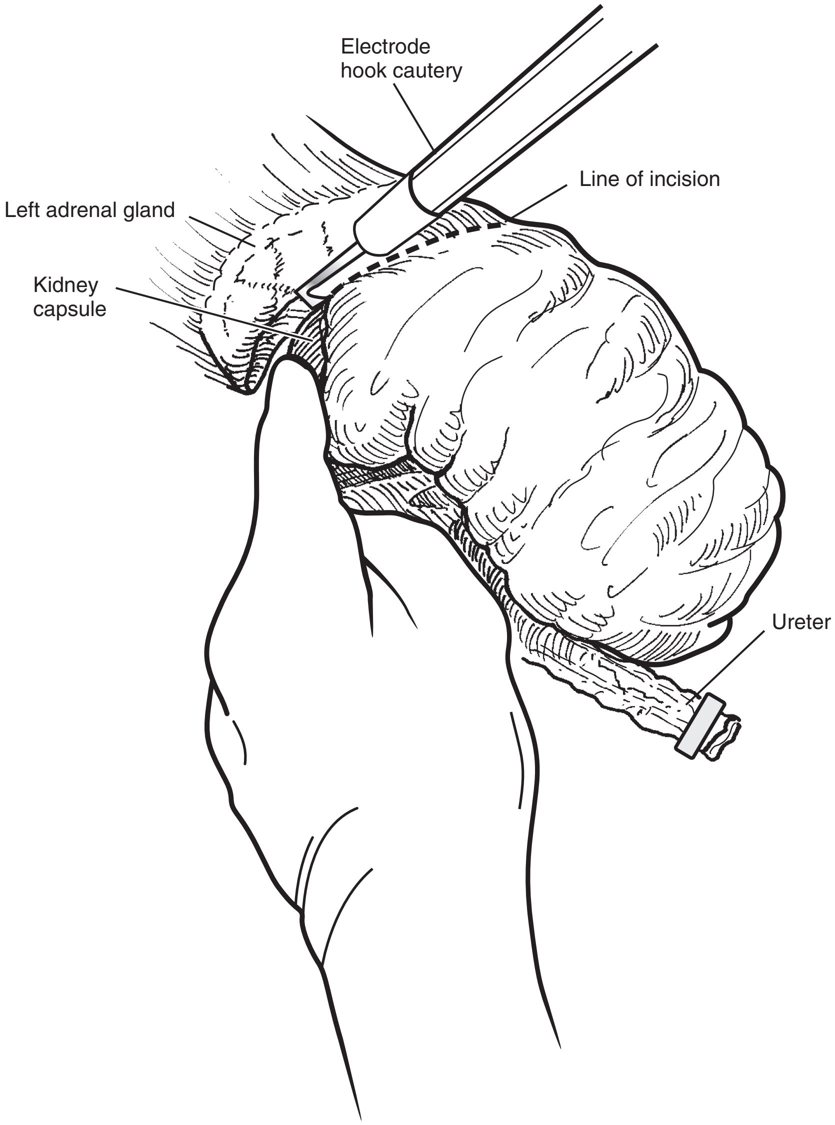


FIGURE 7–6. Adrenal vein preservation and upper pole dissection. Superomedial attachments can be taken close to renal capsule if radiographic images show the tumor to be far from the adrenal gland. A hook cautery is ideal for this dissection. Blunt dissection can assist with this maneuver.

COMPLICATIONS

The complications of HALRN are essentially the same as those of standard laparoscopic nephrectomy. There are no complications unique to HALRN except for the previously mentioned wound hernias associated with paramedian hand port incisions.

One of the main advantages of hand-assistance is that the surgeon can apply direct pressure to any bleeding point. It would be unusual to have any bleeding situation that would require emergent conversion to open surgery. Also, having tactile feedback can help avoid injury by being able to palpate for arteries before dividing tissue.

Tips and Tricks

- Retract liver with 2-mm instrument, as shown in Figure 7–7. If needed, use a 2-mm trocar and 2-mm locking grasping forceps to tent up the liver edge. Attach the forceps to the lateral ligament and to the liver. It is important to place the trocar high enough at the xiphoid process to prevent the liver edge from slipping off the shaft of the forceps.
- A “baby” vascular clamp is used to control bleeding. If significant bleeding of the vena cava is incurred, place a short-handled Allis clamp through the hand port and use it to clamp the bleeder. Then place a hemostatic figure-of-eight suture.

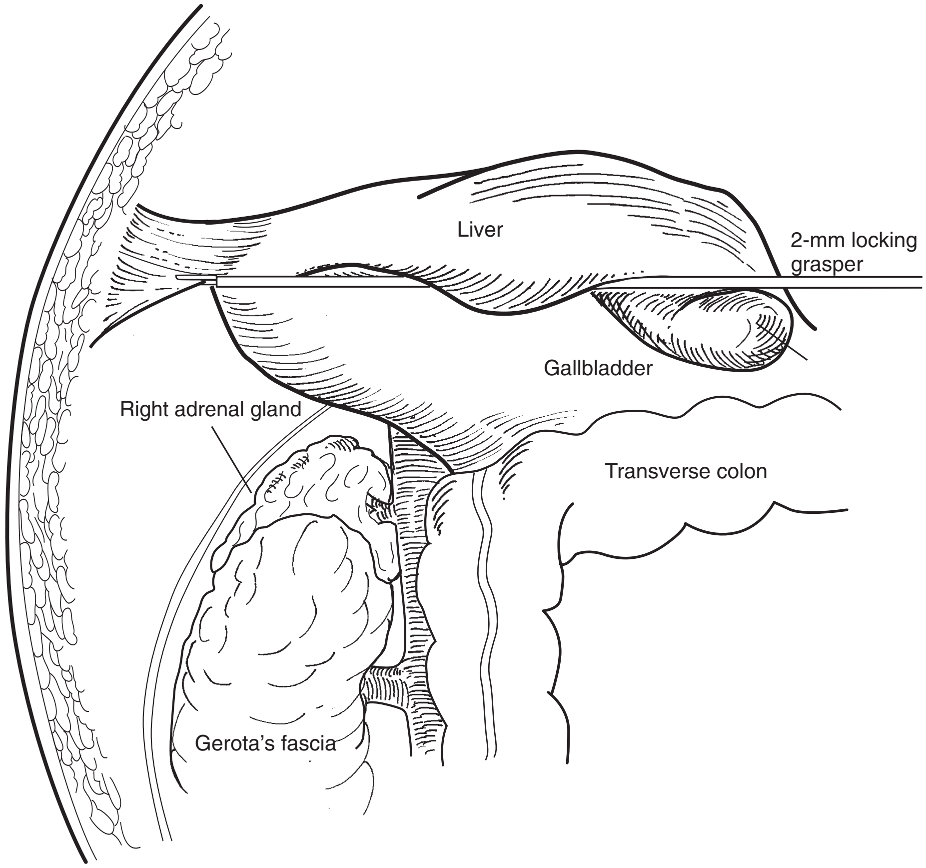


FIGURE 7–7. Liver retraction. A 2-mm locking forceps can be used to tent up the liver edge and act as a self-retraining retractor.

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2. Wolf JS, Moon TD, Nakada SY: Hand-assisted laparoscopic nephrectomy: Technical considerations. Tech Urol 3:123–128, 1997.

Hand-Assisted Laparoscopic Radical Nephroureterectomy

Sean P. Hedican
William W. Roberts

In 1991, Clayman and colleagues[1] were the first to report performance of a laparoscopic nephroureterectomy for the management of upper tract transitional cell cancer. The use of a hand-assist device as an adjunct to laparoscopic renal surgery was not described until 1997 by Nakada and associates.[2] The following year Wolf and colleagues[3] applied this hand-assist technology to aid in the performance of a laparoscopic nephroureterectomy. Since this introduction, several surgical groups have confirmed equivalent oncologic efficacy of hand-assisted laparoscopic compared with open nephroureterectomy with noteworthy improvements in analgesic requirements, length of hospitalization and recovery times.[4,5]

A number of approaches for managing the distal ureter and bladder cuff during standard laparoscopic or hand-assisted laparoscopic nephroureterectomy have been described.[4,6–11] These involve variations of either open, endoscopic, or laparoendoscopic techniques. Approaches also differ based on the need to reposition the patient and whether the distal ureter is dissected at the beginning or end of the operation. The technique chosen primarily depends on the grade and location of the primary tumor as well as individual surgeon preference.

INDICATIONS AND CONTRAINDICATIONS

The primary indication for hand-assisted laparoscopic nephroureterectomy is for the treatment of upper tract transitional cell cancer that cannot be appropriately managed via a ureteroscopic or percutaneous approach. In general, these are the same patients who are candidates for open radical nephroureterectomy. This would include patients with large, moderate to high-grade cancers or lower-grade cancers that are have failed prior endoscopic management. The approach to the distal ureter is often determined by the location and grade of the lesion and whether periureteral intravesical disease exists. In cases of high-grade ureteral cancers distal to the iliac vessels or coexisting periureteral/intravesical tunnel disease, open excision of the distal ureter with removal of a surrounding cuff of bladder is the preferred approach. All of the other tumor scenarios can be approached using an open excision or any of the endoscopic or laparoendoscopic techniques presented later.

Contraindications unique to performing hand-assisted laparoscopic radical nephroureterectomy in general are relative. These include bulky tumor with significant adenopathy and adjacent organ or major vascular involvement. Patients with an ipsilateral stoma, prior aortic bypass surgery, or other extensive prior transperitoneal or retroperitoneal surgeries are all relative contraindications.

PATIENT PREOPERATIVE EVALUATION AND PREPARATION

Evaluation of patients consists of standard laboratory assessments including complete blood counts, prothrombin and partial thromboplastin times, and electrolytes. A dipstick and microscopic urinalysis should be performed to rule out the presence of infection. In addition to being typically more advanced in age, patients with urothelial cancers often have a significant tobacco exposure history, much like patients undergoing cystectomy; therefore, a preoperative electrocardiogram should be performed to rule out the presence of occult cardiac disease.

Imaging includes an abdominal-pelvic computed tomography (CT) scan with and without contrast to define the extent of disease and a screening chest radiograph to search for occult primary or metastatic pulmonary lesions. In patients in whom the creatinine is elevated, a magnetic resonance imaging (MRI) scan is preferred over a CT scan because MRI does not require administration of potentially nephrotoxic contrast. Differential nuclear renal scan imaging in these patients with reduced renal function is also helpful to establish the risk of subsequent renal decline following removal of the affected kidney.

On the day before the operation, the patient goes on a clear liquid diet and a mechanical bowel preparation of the colon is performed following the evening meal. Decompression of the large bowel improves the postoperative return of bowel function; limits intraoperative distention of the bowel, aiding in dissection; and reduces the risk of fecal soiling, thus improving the chances of a primary repair if a descending colon injury should occur. Reduced blood flow in the femoral veins due to the presence of the pneumoperitoneum has been associated with deep venous thrombosis; therefore, the patient wears thigh-high compression hose and uses sequential pneumatic devices on the lower extremities. An orogastric tube is placed following intubation and a Foley catheter is inserted unless initial endoscopic release of the ureter is desired.

OPERATING ROOM CONFIGURATION AND PATIENT POSITIONING

Configure the operating room in a fashion that facilitates the actions of the primary surgeon and interactions with the first assistant and the surgical nurse or scrub technician. During the laparoscopic portion of the operation or while performing an open bladder cuff removal, position a Mayo stand over the

patient's legs. Place the laparoscopic equipment used most frequently here to facilitate rapid access. Place the primary equipment table below the patient's feet; it extends in an L-configuration away from the primary surgeon. Locate a secondary table in line with the primary table and place the standard open operative equipment on it in case there is need for an urgent conversion to open surgery.

Position the primary tower containing the insufflation machine, light source, camera receiver, and monitor across the table from the surgeon at the head of the operating table. This allows direct visual assessment of the insufflation pressures, flow rates, and instrument settings throughout the case. Secure insufflation tubing, camera cord, and the light cable within created folds of the drapes or with Velcro straps on designated laparoscopic drapes. Bring the ends of the cords and tubing off the head of the table and insert them into the appropriate device on the primary tower.

Position the secondary tower in a similar place on the ipsilateral side of the primary surgeon for visualization by the assistant and scrub nurse or technician. Make sure the monitors provide an unobstructed view at eye-level height or slightly below to prevent inadvertent upward head tilt throughout the operation, which can lead to cervical fatigue. A platform of short step stools can be created to facilitate this if the monitor tower height does not allow adjustment to eye level or below. Adjust operative table height so that it is high enough to prevent crouching with associated downward distraction of the nondominant shoulder as the hand is inserted deeply into the abdominal cavity. Make sure that the table is not so high that the shoulders are maintained in a shrugged position because this can accelerate fatigue and muscle cramping.

Place the suction device adjacent to the anesthesia machine at the head of the table on the same side as the primary surgeon, and hang the irrigating fluid bag from one of the intravenous fluid poles on either side of the table. Place the electrocautery unit and harmonic generator toward the foot of the table opposite the primary equipment table on the same side as the operating surgeon.

Initial patient positioning depends on the desired approach to the distal ureter. If planning an initial endoscopic release of the ureter, then place the patient in the dorsal lithotomy position. Following completion of this portion of the operation or during initial positioning for all other approaches, place the patient in a full flank or semiflank position with the affected side up. Insert an axillary roll if the patient's flank is beyond 30 degrees of horizontal in order to prevent brachial plexus injury. Place the operative table in a small amount of flexion with the kidney rest minimally elevated to the point where it fills the gap created in the operative table due to the flexion. The surgical field during laparoscopy is the peritoneal cavity, and extreme flexion of the table reduces this field by forcing the viscera and paraspinal musculature toward the opposite side, which is why flexion should be minimized.

Apply 3-inch foam padding to the operative table; this reduces the likelihood of neuromuscular injuries caused by the length of the operative procedure. Separate the lower extremities by pillows placed perpendicular to the legs in order to limit the likelihood of the legs rolling off the pillows as the table is rotated. Insert pillows adequate to separate the legs without abducting the thighs beyond shoulder width. Position the pillows high in the crotch with a minimal amount of material extending toward the front of the patient so that access of the inserted arm is not limited. Place two arm boards side-by-side on the contralateral side of the table to the patient's pathology. Cover the arm boards with eggcrate foam, and place the patient's down arm on the foam. Stack pillows parallel to and between the two arms until the arms are resting shoulder width apart.

Stabilize the patient on the table by placing a gel roll behind his or her lumbar spine, which is then secured using a double-jointed support arm. Place a folded towel on the upper arm from the elbow to the shoulder. The towel covers the upper hip and extends across the genital area. Secure 3-inch cloth tape to the table, pass it across the towel on the patient's hip, and attach it to the contralateral table edge. Pass the tape from the table, across the top shoulder, to the elbow, then split the tape, extend it on either side of the stack of pillows, and attach it to the undersurface of the arm boards. Place tape or a wide-extremity Velcro strap over the area of the lower legs. Place the head on a foam ring or pillows to keep it in a neutral position, and secure a foam block behind the patient's head. All of these maneuvers are designed to secure the patient to prevent significant movement during airplaning of the table.

TROCAR PLACEMENT

Right Side

The configuration of laparoscopic port placement depends on the surgeon's hand dominance and on the management plan for the distal ureter. Typically, surgeons insert the nondominant hand into the abdomen in a position far enough from the kidney to allow elevation and stretch of the hilar structures but not too far to allow comfortable access to all regions of the kidney. For right hand–dominant surgeons operating on right-sided tumors, the hand-assist device is inserted into the right lower quadrant in a position approximately midway between the umbilicus and the superior iliac crest (Fig. 8–1*A*). This is similar to a McBurney incision for open appendectomy; however, it is angled slightly medial and inferior in line with the fibers of the external oblique musculature. The incision can be extended further downward in a standard Gibson fashion if the distal ureter is to be managed in an open fashion.

Insert a 10/12-mm port at the level of the umbilicus in patients with a normal body mass index (<30 BMI). Shift the port lateral and cephalad in obese patients as required by the enlarged pannus; this shift in the skin incision helps to maintain the appropriate trocar entry point into the fascia. Insert a 10/12-mm port for introduction of the laparoscope in the epigastrium near the midline or shift it toward the midclavicular line in more obese patients. Maintain the space between the trocars in the periumbilical and epigastric regions at approximately the distance between the index and little finger.

A third (5-mm) port is often required for right-sided lesions in order to maintain adequate liver retraction. Place this port in the posterior axillary line between the iliac crest and the 12th rib or, alternatively, just below and lateral to the xiphoid process in the region of the epigastrium. If performing laparoscopic or endoscopic management of the distal ureter, an additional 10/12-mm port may be required midway between the umbilicus and the pubic symphysis to facilitate dissection and/or securing of the distal ureter.

Left hand–dominant surgeons place the hand-assist port in a periumbilical location with the incision centered below the

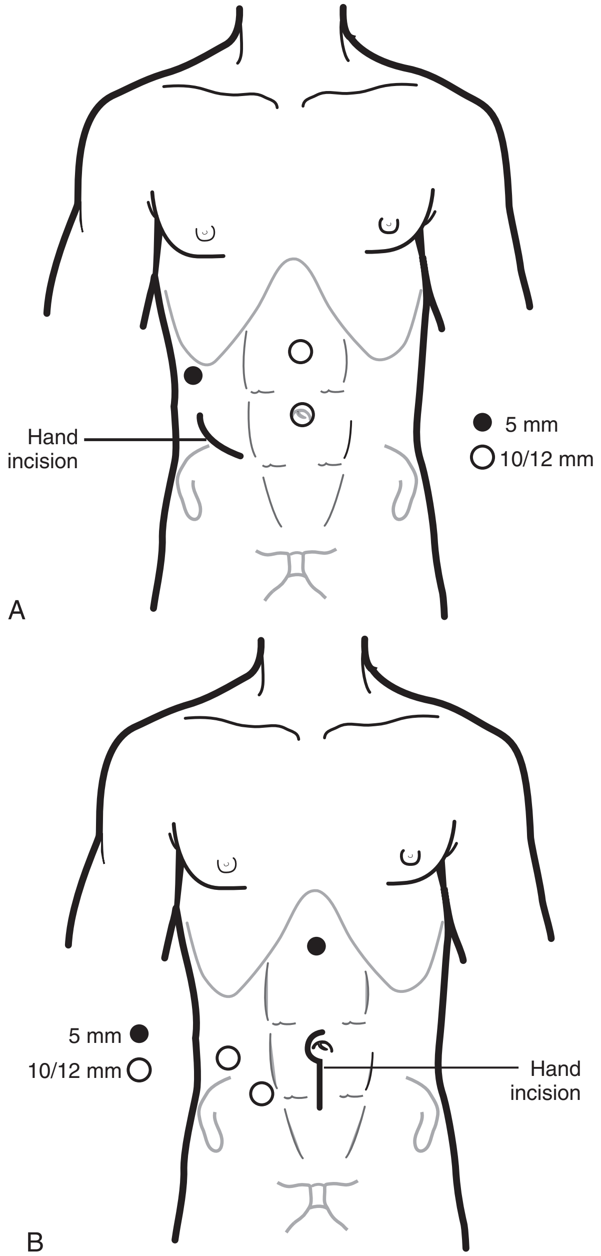

FIGURE 8–1. *A,* Port placement for a right-sided nephroureterectomy performed by a right hand–dominant surgeon. *B,* Port placement for a right-sided nephroureterectomy performed by a left hand–dominant surgeon. In both clinical scenarios, an additional 10/12-mm port can be inserted midway between the pubic symphysis and umbilicus to facilitate securing the distal ureter. In obese patients, the trocar and hand incisions are shifted lateral and cephalad to avoid the thickest regions of the pannus.

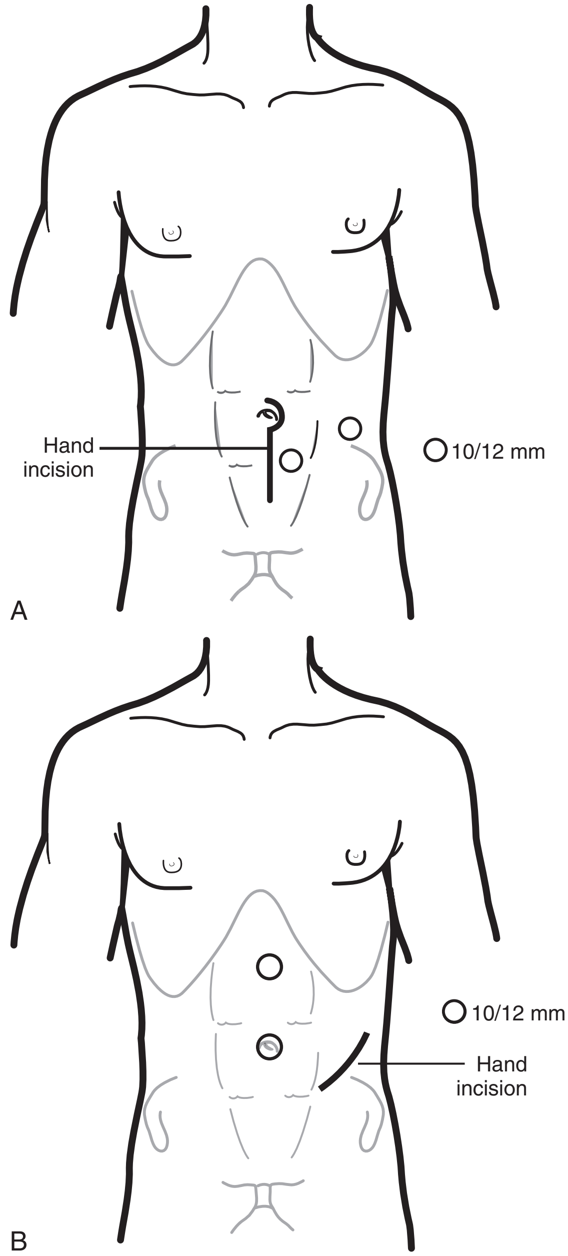

FIGURE 8–2. *A,* Port placement for a left-sided nephroureterectomy performed by a right hand–dominant surgeon. *B,* Port placement for a left-sided nephroureterectomy performed by a left hand–dominant surgeon. An additional 10/12-mm port midway between the pubic symphysis and umbilicus may be required to aid in securing the distal ureter. The trocars and hand-assist device are inserted more lateral and cephalad in morbidly obese patients.

umbilicus if an open excision of the distal ureter and bladder cuff is planned. In this approach, extend the midline incision downward to facilitate that portion of the operation. If an endoscopic approach to the distal ureter is anticipated, center the incision on the umbilicus (see Fig. 8–1*B*). Insert the 10/12-mm working port midway between the umbilicus and the iliac crest, which is usually just lateral to the rectus muscle. Place an additional 10/12-mm port in the anterior axillary line midway between the top of the iliac crest and the 12th rib for insertion of the laparoscope. Insert a 5-mm port lateral and below the xiphoid process if liver retraction is required. An additional 10/12-mm trocar may be required midway between the umbilicus and pubic bone to allow dissection and securing of the distal ureter.

Left Side

For right hand–dominant surgeons, the trocar configuration for a left-sided hand-assisted laparoscopic nephroureterectomy is essentially the mirror image of the ride-sided configuration for the left hand–dominant surgeon (Fig. 8–2*A*). Place the hand-assist port in a periumbilical location with the incision

centered below the umbilicus when an open distal ureteral excision is planned. Insert a 10/12-mm port midway between the umbilicus and the iliac crest, and place a similar port in the anterior axillary line midway between the top of the iliac crest and the 12th rib to accommodate the working instruments and the laparoscope, respectively. An accessory port for liver retraction is unnecessary; however, an additional port is often required midway between the umbilicus and the symphysis pubis if the distal ureter is managed endoscopically.

The port configuration for a left hand–dominant surgeon performing a left nephroureterectomy is the mirror image of the configuration used by a right hand–dominant surgeon to perform a right-sided nephrectomy (see Fig. 8–2*B*). Select a left lower quadrant location between the umbilicus and iliac crest angling medial and inferior for insertion of the hand-assist device. Place a 10/12-mm port in the periumbilical region for insertion of the working instruments and in the epigastrium just lateral to the midline for the laparoscope. Insert an additional 10/12-mm port midway between the umbilicus and symphysis pubis to facilitate dissection of the distal ureter, if needed.

BOX 8–1. Special Instruments

1. **Diamond Flex Triangle retractor** (Genzyme Surgical Products, Tucker, GA)—Liver retraction during right-sided nephroureterectomy
2. **5-mm Harmonic scalpel** (Ethicon Endo-Surgery, Cincinnati, OH)—Hemostasis, dissection, and transection of small vasculature
3. **Endovascular-GIA stapler** (Ethicon Endo-Surgery; or U.S. Surgical, Norwalk, CT)—Securing and dividing renal artery, renal vein, and the bladder cuff
4. **Surgitie** (U.S. Surgical)—Securing the mobilized cuff of bladder and distal ureter during initial transvesical laparoscopic release
5. **Hand-assist device**—Latest-generation devices not requiring a sleeve or adhesives
   - **GelPort** (Applied Medical, Rancho Santa Margarita, CA)—Unique gel matrix maintains pneumoperitoneum even during hand exchanges and allows for direct insertion of instruments or ports.
   - **LapDisc** (Ethicon Endo-Surgery)—Adjustable iris maintains pneumoperitoneum.
   - **Omniport** (InterMed, Selling, NV)**—**Twisted pneumatic tube maintains the pneumoperitoneum.

PROCEDURE

Create the Pneumoperitoneum

The pneumoperitoneum can be established using one of two methods. Early-generation hand-assist devices required establishment of the pneumoperitoneum before insertion of the hand device due to the reliance on adhesives to secure the device to the abdomen. This necessitated a taught abdomen without creases or folds. Using this method, make a 1-cm incision in the ipsilateral lower quadrant through which trocar insertion is planned, and blindly insert an insufflation (Veress) needle into the peritoneal cavity via the incision. On introduction of the needle, elevate the surrounding tissues in the grasp of the nondominant hand or using towel clips. Two audible and tactile snaps are experienced as the needle traverses first the tough outer fascia and then enters the peritoneal cavity. Entry into the peritoneum is confirmed by uninhibited movement of the needle tip by rocking it back and forth and injecting free flowing saline into the hub of the needle (Box 8–1).

Newer-generation hand-assist devices do not require the use of adhesives, and therefore it is not necessary to create the pneumoperitoneum before inserting the device. This allows the hand-assist port incision to be made first with insertion of the hand-assist device under direct vision, thus reducing the risk of bowel injury. Use the inserted hand to explore the peritoneal cavity. Directly access adhesions in the vicinity of the hand-assist device through the port incision and take them down. Ensure that the parietal peritoneum around the edge of the incision is clear in order to allow secure placement of the inner ring of the hand device and to prevent bowel or omental entrapment. After placing the hand-assist device, insert the nondominant hand with the insufflation tubing cupped in the palm, which allows establishment of the pneumoperitoneum. An alternative method of insufflating the abdomen involves placing a laparoscopic port through the hand device, which is secured around this trocar as if it were the inserted hand. Then establish pneumoperitoneum via this port, and introduce the laparoscope, allowing direct visualization on placement of subsequent trocars.

Place the Port

Once the pneumoperitoneum is established and the sites for port placement are selected, make a skin incision for the trocar, spread the subcutaneous tissues, and cup the introduced hand beneath the area of port introduction as the parietal peritoneum is tented inward by the advancing trocar. Advance each port into the peritoneum using a gentle back-and-forth twisting motion. Only do this using nonbladed trocars in order to prevent injury to the hand. After introducing the initial port, insert the laparoscope through this port to allow direct visualization while introducing the other ports. The back of the hand protects the viscera and vasculature from inadvertent injury.

If an insufflation and visualization trocar was inserted via the hand-assist port, the laparoscope is used via this port to visualize insertion of all subsequent ports using the earlier-noted techniques and port configurations.

Expose the Retroperitoneum

Once the ports are inserted, incise the line of Toldt along either the right or left pericolic gutter. On the left, carry the incision cephalad to release all of the splenic attachments so that the spleen and tail of the pancreas can be reflected medially en bloc with the colon (Fig. 8–3). It is important to continue to release the spleen until the greater curvature of the stomach is seen because this will ensure adequate cephalad exposure of the kidney. On reflection of the colon and its mesentery, take care to remain in the plane between the slightly darker yellow and irregular fat of the mesentery and the lighter, smoother Gerota's fat layer contained within its fascia. This can be especially difficult in thinner patients and can result in inadvertent entry into the colon mesentery.

On the right side, incise the attachments of the liver to the diaphragm (triangular ligament) and the colon (coronary

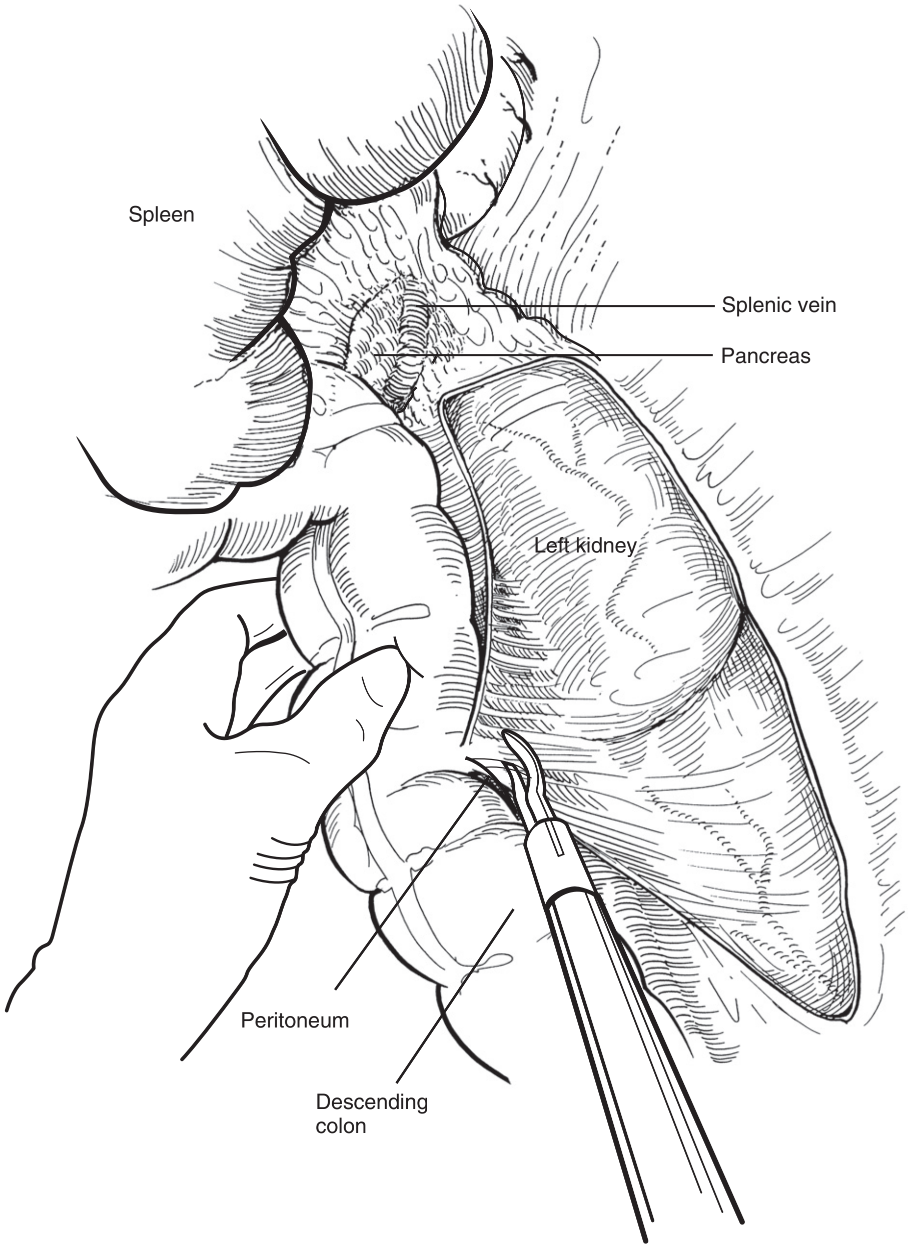

FIGURE 8–3. Incision of the line of Toldt is carried cephalad to release the splenic attachments allowing en bloc medial mobilization of the descending colon, mesentery, spleen, and tail of the pancreas exposing the greater curvature of the stomach. The left retroperitoneum is now completely exposed.

ligament) in a similar fashion. Insert a liver retractor via the lateralmost trocar and use it to elevate the liver edge. We prefer the Diamond Flex Triangle retractor (Genzyme Surgical Products, Tucker, GA) because it can be inserted via a 5-mm port and, when configured, it forms a broad triangle that provides a wide surface for elevation with few significant pressure points to cause capsular injuries. Then medially reflect the ascending colon. Near the region of the hilum, the duodenum is usually the first structure encountered because it overlies the surface of the vena cava and can be confused for it. Exercise great care in releasing and kocherizing the duodenum because excessive traction can result in serosal tears and vigorous applications of energy can cause thermal injuries, both of which can result in delayed duodenal leaks. Once the duodenum is released and swept medially, the vena cava can often be seen as a smooth blue-hued structure running in a craniocaudad direction.

Identify the Ureter

Once the colon and its mesentery have been swept sufficiently medial, identify the ureter, which is a bandlike tubular structure lying slightly posterior and lateral to the overlying gonadal vein. It is often easiest to locate the ureter just before it crosses the readily visualized pulsations of the iliac artery and dives into the pelvis. A gentle squeeze and corresponding peristalsis of the isolated structure confirm its identity. Use the thumb

and forefinger of the introduced hand to encircle the ureter and elevate it in a cephalad and lateral direction. Use the harmonic shears to create a window beneath the ureter, coagulating before dividing areas of resistance, which often contain small medial-based feeding vessels. Carry the dissection cephalad to the renal pelvis and distal across the iliac vessels. Place several titanium clips or a single Hem-o-loc clip (Weck, Research Triangle Park, NC) on the ureter below the area of known tumor early in the dissection to prevent the efflux of cancer cells if a distal ureteral dissection technique will be used where the bladder is opened. Sweep the gonadal vein medially and exclude it from the dissection, especially on the right where it has a very fragile entry point into the vena cava.

Dissect the Hilar Structures

On the left side, the main renal vein can readily be identified by tracing the gonadal vein cephalad to its confluence with this structure. On the right side, the lateral edge of the vena cava is followed cephalad until the base of the main right renal vein is identified merging with the vena cava. Once identified, clear the overlying fibrofatty tissue from the anterior surface of the main renal vein by using the thumb and forefinger like a grasping instrument to pick it up and the harmonic shears to transect and peel it away. Once the anterior surface has been cleared on the left side, perform circumferential dissection of the draining branches of the gonadal and ascending lumbar veins. The ascending lumbar vein is nearly always present; it is located medial and posterior to the gonadal vein and crosses the base of the main left renal artery. When these vessels are small, coagulate and transect them using the harmonic shears on a coagulative setting; this provides excellent hemostasis. When these vessels are more substantial, two proximal and two distal clips with transection between are preferred.

Once these branches are released, further develop the space between the vein and the base of the artery by gently grasping the vein or using the back of the index finger to draw it cephalad and medial. Use the harmonic shears, if needed, to grasp and divide the fibrofatty lymphatic tissue that lies between the artery and vein while using the hand to elevate the lower pole of the kidney laterally, placing the hilum on stretch. Identify the main left adrenal vein as it enters the upper edge of the main renal vein, typically in a location medial to the entry point of both the gonadal and lumbar vein branch. If the adrenal gland is to be spared and the distance between the main renal vein segment lateral to the adrenal vein entry point and its first branch point is substantial enough to allow passage of the Endovascular-GIA stapler (~1.5 cm), then leave the adrenal vein intact. If the space is not adequate, circumferentially dissect the main adrenal vein and either coagulate and transect it using the harmonic shears or clip and divide it as described for the other branches of the main renal vein.

On the right side, the corresponding branches enter directly into the vena cava. The entry point of the gonadal vein is traditionally one of the weakest points on the vena cava, and while dissecting the ureter cephalad to the hilum, medially sweep the gonadal vein at its base. Then separate the entire length of the gonadal vein from the ureteral package and dissect it medially to remain on the surface of the cava. Alternatively, circumferentially dissect the base, doubly clip it, and transect it if separation cannot readily be performed.

Mobilize the Kidney

Once the hilar branches have been secured, release the attachments lateral to Gerota's fascia using the harmonic shears. Grasp the lower pole between the thumb and forefinger, elevate it, and rotate it medially while carrying out the dissection cephalad toward the upper pole. Continue moving until the kidney can be released and remains in full medial rotation to allow access to the artery from a posterior approach. Drape the hand over the kidney, and use the thumb and index finger together to elevate, coagulate, and divide the fibrofatty tissue around the artery. Carry the dissection down to the adventitial surface of the artery, clearing the entire posterior surface until a right angle can be readily passed around the artery and spread to allow adequate space for introduction of the Endovascular-GIA stapler. Push the lymphatic and fatty tissue between the artery and vein forward using the index and middle fingers, then grasp and divide it using the harmonic shears. Eventually, pass the fingers and thumb entirely around the vein and artery, allowing complete control of the hilum.

Secure the Hilum

Once the main renal vessels have been dissected to the extent described earlier, introduce the Endo-GIA stapler via the lower quadrant port. Leave the kidney in its medially flipped position, exposing its posterior surface, and use the thumb and forefinger to grasp and elevate the artery away from the vein to allow insertion of the Endo-GIA stapler. It is usually easier to pass the thinner anvil side of the stapler between the artery and vein with the cartridge (white) side of the stapler on the posterior surface. Grasp and medially stretch the kidney to give better visualization of the arterial length while closing the stapler around the artery. Alternatively, elevate the kidney toward the abdominal wall and insert the jaws of the stapler around the artery (Fig. 8–4). Inspect the stapler to make sure the artery lies completely within the two end marking lines that designate the extent of the staple line and to ensure that no clips are in the jaws of the stapler. Once this is confirmed, fire the stapler, laying down six rows of staples with the blade cutting between rows 3 and 4.

On the right side, it is often more difficult to release the posterior and cephalad attachments to the point where the kidney can be released and will maintain a medially rotated position. In these situations, the base of the artery can usually be identified by using the back of the hand to elevate the lower pole of the kidney and the ureter in a cephalad and lateral direction. Use the index and middle fingers to partially encircle and present the artery below and lateral to the vein to aid in dissection. Once the tissue around the artery is removed, grasp the lower pole of the kidney and elevate it toward the abdominal wall as described earlier. Then secure the artery and divide it using the Endo-GIA stapler. Alternatively, place two or three Hem-o-loc clips on the base of the artery with one clip on the kidney side and the artery divided between clips using the cold shears.

The vein is handled in a fashion similar to the artery. On the left side, it is particularly important to pay close attention to any clips on the vein branches entering the main renal vein before placing the Endo-GIA stapling device. One advantage of the introduced hand is the ability to feel the surface of the

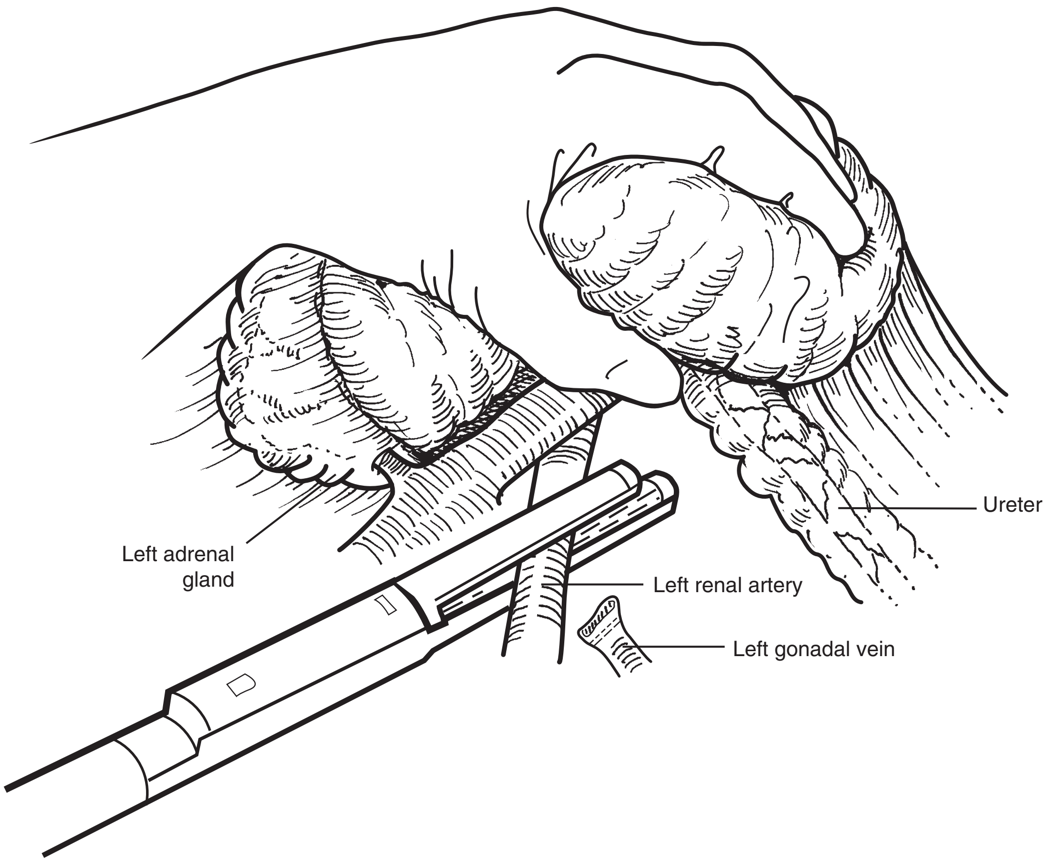

FIGURE 8–4. Securing the main left renal artery using an Endo-GIA stapler. The lower pole of the kidney is held in a lateral and cephalad direction to expose the space between the main renal vein and renal artery. The gonadal and lumbar vein branches have been secured and divided to facilitate access to the artery.

vein to prevent incorporation of previously placed clips into the jaws of the stapling device, which can result in stapler malfunction and profound hemorrhage. On the right side, there is less risk of incorporating clips due to the typical absence of significant feeding branches into the main renal vein, but the short vein length often leaves little, if any, stump on the vena cava that can be grasped or clipped should bleeding occur. It is therefore important to leave as much stump as possible just in case a stapler may fail, lock up, or provide an inadequate seal of the vessel (Fig. 8–5).

Release the Cephalad Attachments and Dissect the Distal Ureter

Once the hilar vessels are secured and divided, the only remaining attachments of the kidney lie between the adrenal gland and the upper pole. If the adrenal gland is radiographically normal in appearance and to palpation, it can be spared. The harmonic shears are the ideal instrument to seal and divide the small network of vessels supplying the adrenal gland. Once the yellow-orange edge of the gland is identified, use the harmonic shears to grasp and divide the tissue, staying flush with the edge of the adrenal until the kidney is completely free.

If the adrenal gland is to be removed as part of the specimen, continue the dissection along its medial surface after securing the renal hilum. The main renal vein in this scenario on the left side will have been divided medial to the entry point of the main adrenal vein. Continue the dissection between the lateral surface of the aorta and the medial edge of the adrenal gland using the harmonic shears. Use the harmonic shears to safely divide all arterial branches *except* the middle adrenal artery arising directly from the aorta; this artery is often substantial and requires securing with clips. On the right side, the dissection proceeds along the lateral edge of the inferior vena cava until the main adrenal vein is identified entering into the posterolateral surface of the vena cava. Encircle the vein with the right-angle clamp and control it with standard titanium clips, Hem-o-loc clips, or the Endo-GIA stapler. Divide the remaining cephalad connections using the harmonic shears.

Following completion of the radical nephrectomy portion of the operation, inspect the renal fossa under high and low insufflation pressures to evaluate for any residual bleeding points. Obtain hemostasis using a combination of electrocautery, harmonic shear coagulation, and selective applications of surgical cellulose (Surgicel; Johnson & Johnson, Arlington, TX) when necessary.

Dissect the ureter down to its entry point into the intravesical tunnel using a combination of blunt hand dissection and selective tissue division with the harmonic shears. The superior vesical artery is encountered as it crosses over the distal aspect of the ureter and often requires securing with clips before division. If needed, place an additional suprapubic 10/12-mm trocar in the midline or several centimeters toward the contralateral side midway between the umbilicus and pubic symphysis to facilitate the dissection and allow application of an Endo-GIA stapler on the bladder cuff. When the GelPort hand-assist

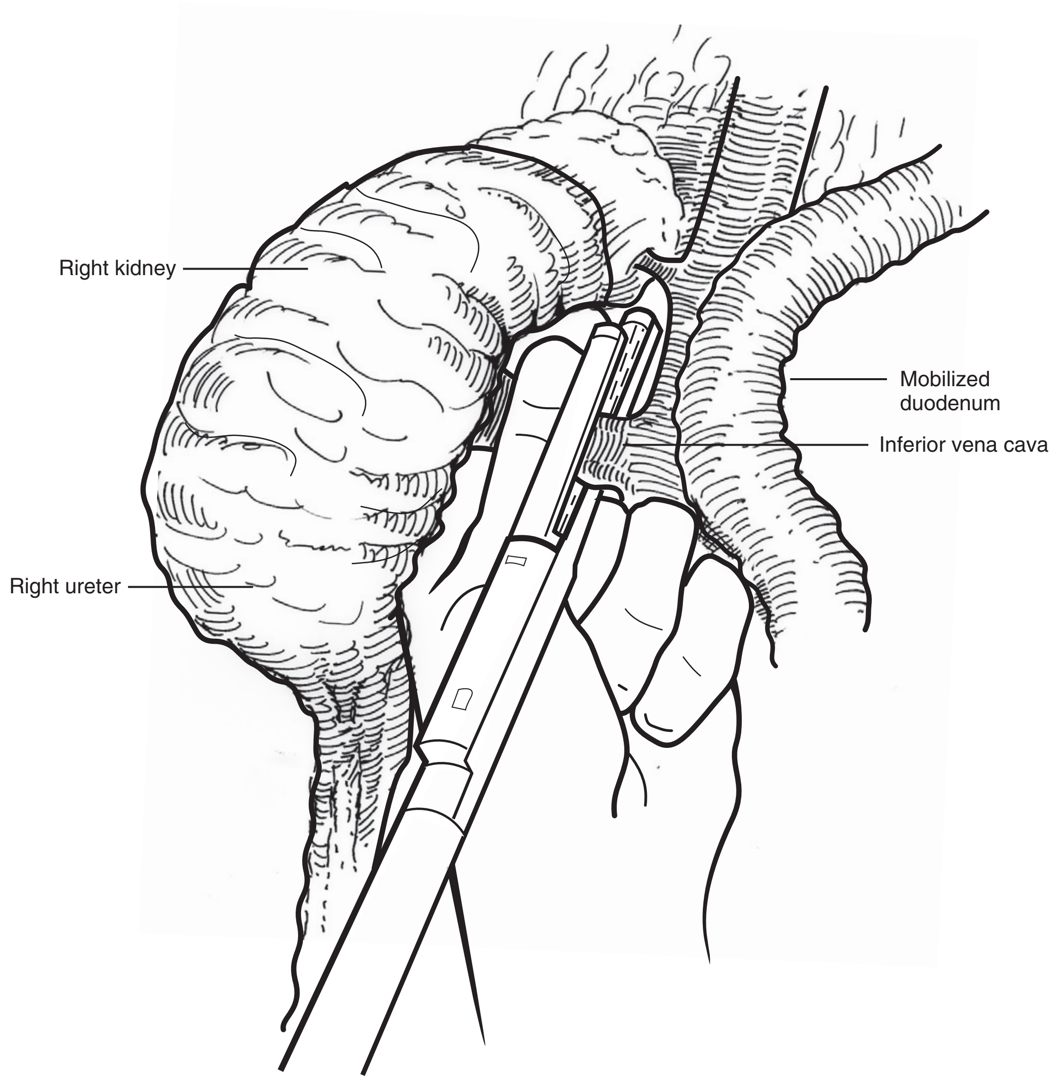

FIGURE 8–5. Securing the main right renal vein using an Endo-GIA stapler. The thumb and fingers can be used to retract the hilar fat and place the vein on stretch in an effort to obtain greater stump length on division of this structure. Note that the duodenum has been kocherized to expose the surface of the inferior vena cava.

device is used, another option for performing the distal ureteral dissection is to insert additional instruments directly through the gel matrix, thus eliminating the need for an additional trocar.[12] Or remove the hand from the hand-assist port when a lower quadrant incision is used and perform a standard laparoscopic dissection using instruments inserted directly through the hand-assist and the periumbilical ports.

Manage the Distal Ureter

Open Resection With Bladder Cuff Removal

Many surgeons believe that open resection of the distal ureter and associated cuff of bladder is the preferred approach for high-grade cancers of the distal ureter or in the setting of periureteric or intravesical ureteral tumors. This is most efficiently accomplished by performing an open excision in standard fashion by extending the hand-port incision. This portion of the operation is typically performed after repositioning and reprepping the patient following the hand-assisted laparoscopic nephrectomy.[6] If a midline incision was made for insertion of the hand-assist device, extend it to the pubic symphysis, whereas if a lower quadrant incision was made, extend it in an inferomedial Gibson fashion.

Insert the preferred self-retaining pelvic retractor (e.g., Balfour), and place a clip or tie on the distal ureter to prevent the passive efflux of potential cancer-bearing urine. Open the bladder via a midline incision that is extended down to the bladder neck and use a bladder blade to open the bladder and elevate the trigone. Circumscribe the bladder cuff using electrocautery and continue the dissection through the detrusor muscle until the cuff is fully released. Then close the ureterovesical junction hiatus and anterior bladder wall in two layers. If desired, bring the end of a 15-French round Davol drain out through one of the port incisions if readily accessible to the pelvis or place it through an ipsilateral lower pelvic stab incision.

Chen and associates[7] described their modified approach in which the open distal ureterectomy and bladder cuff excision is performed first through an ipsilateral Gibson incision. In

their approach, the patient is secured to the operating table in a 60-degree oblique position and airplaned from side to side to provide adequate exposure during different portions of the operation. After completion of the distal ureterectomy, the hand-assist device is inserted into the Gibson incision and used to perform the laparoscopic nephrectomy portion of the operation.

Extravesical Stapling With Endoscopic Unroofing and Fulguration

One of the first methods described for managing the distal ureter and associated bladder cuff consisted of endoscopic unroofing and fulguration of the intravesical ureter and use of an Endo-GIA stapler to secure and divide the bladder cuff. In their early experience with laparoscopic nephroureterectomy at Washington University,[8] Shalhav and associates used endoscopic incision and fulguration of the intravesical tunnel as the initial step of the operation. Using this operative technique, initially place the patient in a dorsal lithotomy position. Use a cystoscope to fluoroscopically insert a 0.035-inch Bentson wire into the affected ureter over which a 7-French 5-mm–wide and 5-cm–long dilating balloon catheter is positioned in the intravesical tunnel and inflated to less than 1 atm. Then use the 24-French resectoscope with a mounted Orandi or similar electrosurgical knife to incise the overlying intravesical tunnel directly over the inflated balloon catheter until it is entirely unroofed. Take care not to extend the incision through the ureterovesical junction. Cauterize the edge of the incision and exposed mucosa using a rollerball electrode. Then exchange the dilating balloon for a 7-French 11.5-mm occlusion balloon catheter, advance it to the renal pelvis, inflate it with 1 mL of dilute contrast medium, and seat it at the ureteropelvic junction to prevent release of tumor cells. Remove the resectoscope and insert a Foley catheter. Secure the occlusion balloon catheter to the Foley and reposition the patient for the hand-assisted laparoscopic nephrectomy portion of the operation.

The steps of the hand-assisted laparoscopic nephrectomy are carried out as outlined earlier until the section, "Identify the Ureter." After identifying and circumferentially isolating the ureter, carry the dissection down to the intravesical tunnel. Complete exposure of this region requires transection of the superior vesical artery. If the bladder cuff is going to be secured using an extravesical Endo-GIA stapling technique, it is advisable to avoid securing the superior vesical artery with clips unless sufficient tenting of the ureterovesical junction away from the clips can be established. If the clips become incorporated into the jaws of the Endo-GIA stapler, a misfire can occur, resulting in inadequate hemostasis and bladder closure. Alternatively, transect the superior vesical artery with the harmonic shears on a coagulative setting or secure the artery with the bipolar cautery before transection.

If desired, introduce the Endo-GIA stapler via a 10/12-mm trocar placed through the matrix of the GelPort[12] for a nephroureterectomy being performed on the side opposite the surgeon's hand dominance (e.g., left-sided specimen in a right hand–dominant surgeon). If not using a GelPort, introduce the stapling device via an optional 10/12-mm port inserted midway between the umbilicus and the pubic symphysis. Insert the stapler via the periumbilical port for procedures performed on the same side as the surgeon's hand dominance, if desired. In this approach, insert the dominant hand through the gel to

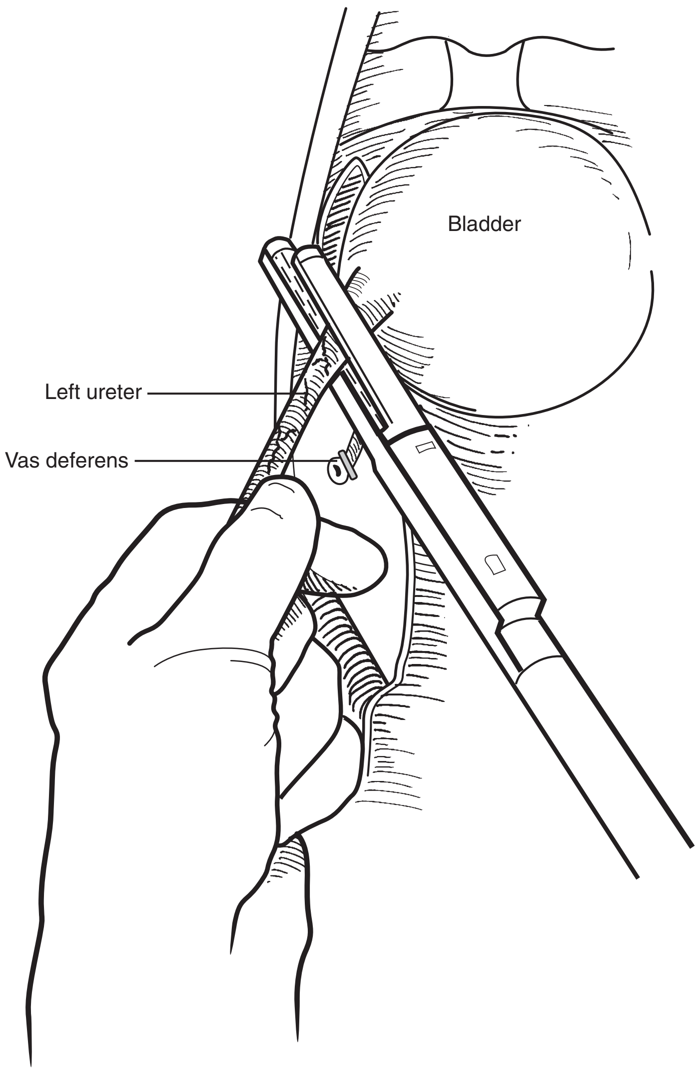

FIGURE 8–6. The ureter is retracted in a lateral and cephalad direction to expose the ureterovesical junction for application of the Endo-GIA stapler in an orientation that will include the outward tented portion of bladder. Care must be taken not to incorporate any clips placed on the superior vesical artery into the jaws of the stapling device.

retract the ureter cephalad and lateral while placing the Endo-GIA stapler across the ureterovesical junction in an orientation that incorporates the surrounding bladder tissue (Fig. 8–6). Before securing the ureter using the Endo-GIA stapler, remove the occlusion balloon catheter and wire to prevent incorporation into the staple line. Fire the Endo-GIA stapler, deliver the specimen via the hand-assist device, and evaluate the area of dissection in the pelvis for hemostasis under high and low insufflation pressures.

An alternative method for use of the previously described method of handling the distal ureter is to perform the hand-assisted laparoscopic nephrouretectomy first, including extravesical stapling of the ureterovesical junction, followed by the endoscopic unroofing procedure. In this approach, perform the hand-assisted laparoscopic nephroureterectomy including dissection and stapling of the ureterovesical junction as outlined earlier (see Fig. 8–6). Remove the specimen and close the laparoscopic incisions as outlined in the section, "Exit the Abdomen

and Close the Port Site," later. Place the patient in the dorsal lithotomy position, reprep, and drape. Insert a 21-French cystoscope with a 30-degree lens and inspect the bladder using glycine irrigant. If the ipsilateral hemitrigone is absent and the staple line is visible in the bladder, then no further endoscopic dissection is required. Before removing the cystoscope, confirm patency of the contralateral ureter by direct observation of the efflux of urine or by having the anesthesiologist administer an intravenous ampule of indigo carmine and observing for blue-tinged urine at the orifice. This helps to ensure that the distal contralateral ureter was not inadvertently kinked during application of the stapling device.

Most often, the ipsilateral hemitrigone is intact and a small portion of the intravesical ureteral tunnel remains. In this scenario, introduce a 6-French whistle-tip catheter into the distal ureter and advance it up the orifice until resistance is encountered at the staple line (Fig. 8–7*A*). Leave the catheter in place, remove the cystoscope, and insert the 24-French continuous flow resectoscope with an Orandi or Collins electrosurgical knife. Use the knife to incise the roof of the intravesical tunnel on top of the catheter until its end is reached (see Fig. 8–7*B*). At this point, remove the catheter; several of the staples from the Endo-GIA application may be visible. Exchange the Collins knife for the rollerball, and use the rollerball to coagulate and ablate the mucosa and edges of the opened distal ureteral segment (see Fig. 8–7*C*). Reinsert the Foley catheter. Extended patient follow-up and experimental animal data have shown no documented evidence of stone encrustation or infection due to titanium staple lines in the urinary tract.[8]

Some surgeons advocate performing the endoscopic unroofing and fulguration of the intravesical tunnel at the time of the patient's initial surveillance cystoscopy. The disadvantage of this approach is that it requires a second anesthetic, but the chief advantage is that it obviates the need for repositioning, thereby reducing the overall time of the initial surgical procedure. This may prove to be advantageous in elderly or debilitated patients or in cases where the physiologic changes of the pneumoperitoneum become prohibitive.

Initial Transvesical Laparoendoscopic Management With EndoCuff

In 1999, Gill and colleagues[11] described another novel technique of securing the distal ureter and surrounding bladder cuff. In this method, place the patient in the dorsal lithotomy position and introduce the 21-French cystoscope with a 30-degree lens into the bladder using glycine irrigant. Distend the bladder and, under direct endoscopic visualization, insert two 2-mm or 5-mm ports 1 cm above the pubic bone and on either side of the midline directly into the bladder. Introduce a 2-mm EndoLoop or Surgitie (U.S. Surgical, Norwalk, CT) via the port overlying the ureter of interest and place the opening around the orifice. Introduce a 6-French open-ended catheter over a 0.035-inch Bentson wire into the distal ureter and through the opening of the EndoLoop. Leave the ureteral catheter in place and exchange the cystoscope for the 24-French continuous flow resectoscope with an attached Collins knife. Then use the Collins knife to score the mucosa at the desired distance around the ureteral orifice, and take care not to encroach on the contralateral orifice. Introduce a 2-mm grasper via the opposite port and use it to grasp the ureter and attached bladder cuff while using the Collins knife to circumferentially incise through the surrounding detrusor muscle and attachments with cautery as indicated to maintain hemostasis (Fig. 8–8*A*). During the procedure, distend the bladder only to the extent necessary for adequate visualization and working space to prevent excessive extravasation of irrigant. The grasper maintains constant anteromedial retraction as the dissection continues until the ureter is freely mobile within the perivesical fat with no residual visualized attachments.

Place the EndoLoop around the bladder cuff and distal ureter while retracting it medially and closing down around the ureter but not cinching. Withdraw the ureteral catheter and guidewire, and, as they pass distal to the EndoLoop, tighten the EndoLoop around the ureter and remove the catheter (see Fig. 8–8*B*). Withdraw the graspers, and insert a 2-mm laparoscopic shear to cut the tail of the EndoLoop to the appropriate length. Exchange the Collins knife for a rollerball attachment, which is used to coagulate 1 to 2 cm of urothelium around the edge of the resection. Withdraw the 2-mm ports under direct visualization, and leave open these sites and the opened ureterovesical junction. Remove the resectoscope, insert a 24-French Foley catheter, and reposition the patient for the hand-assisted laparoscopic nephrectomy as outlined earlier.

Transvesical Endoscopic Management With EndoCuff

Another option for performing resection of the distal ureter and a cuff of surrounding bladder without needing to reposition involves gaining direct laparoendoscopic access to the bladder following completion of the hand-assisted laparoscopic nephrectomy but before port closure. Attach a three-way connector to the Foley catheter to allow easy bladder filling and drainage. Next, distend the bladder with several hundred milliliters of saline, and place the stopcock in the "off" position. Rotate the patient away from the operative surgeon until the abdomen is approximately 45 degrees from the vertical position. Make a 1-cm incision in the midline just above the pubic bone. Fill the bladder with glycine solution and place a radial dilating Step Access System trocar (Weck) through the incision into the bladder. Return of fluid confirms successful entry. Dilate the trocar to 10-mm diameter and insert a 24-French resectoscope mounted with a Collins knife via the trocar. Use two audiovisual towers to provide simultaneous cystoscopic and laparoscopic visualization, if desired. A similar method was described by Gonzalez and associates[9]; however, they introduced a standard 10-mm trocar directly into the distended bladder and used a 24-French offset nephroscope with a Collins knife inserted via its working port.

The intra-abdominal hand helps identify the correct ureteral orifice by alternately pushing and applying traction on the ureter. Under direct vision, score a 1-cm rim of tissue around the ureteral orifice with the Collins knife. Carry the dissection deeper through the detrusor muscle. Traction with the intra-abdominal hand aids in dissection of the intramural ureter. Once the ureter is free, immediately drain the bladder through the Foley catheter to minimize extravasation. Use the Collins knife to achieve hemostasis. Then remove the specimen through the hand-assist port and remove the bladder trocar. It is not necessary to close the defect at the ureteral orifice or the suprapubic trocar site. An indwelling Foley catheter maintains bladder decompression for 7 to 10 days.

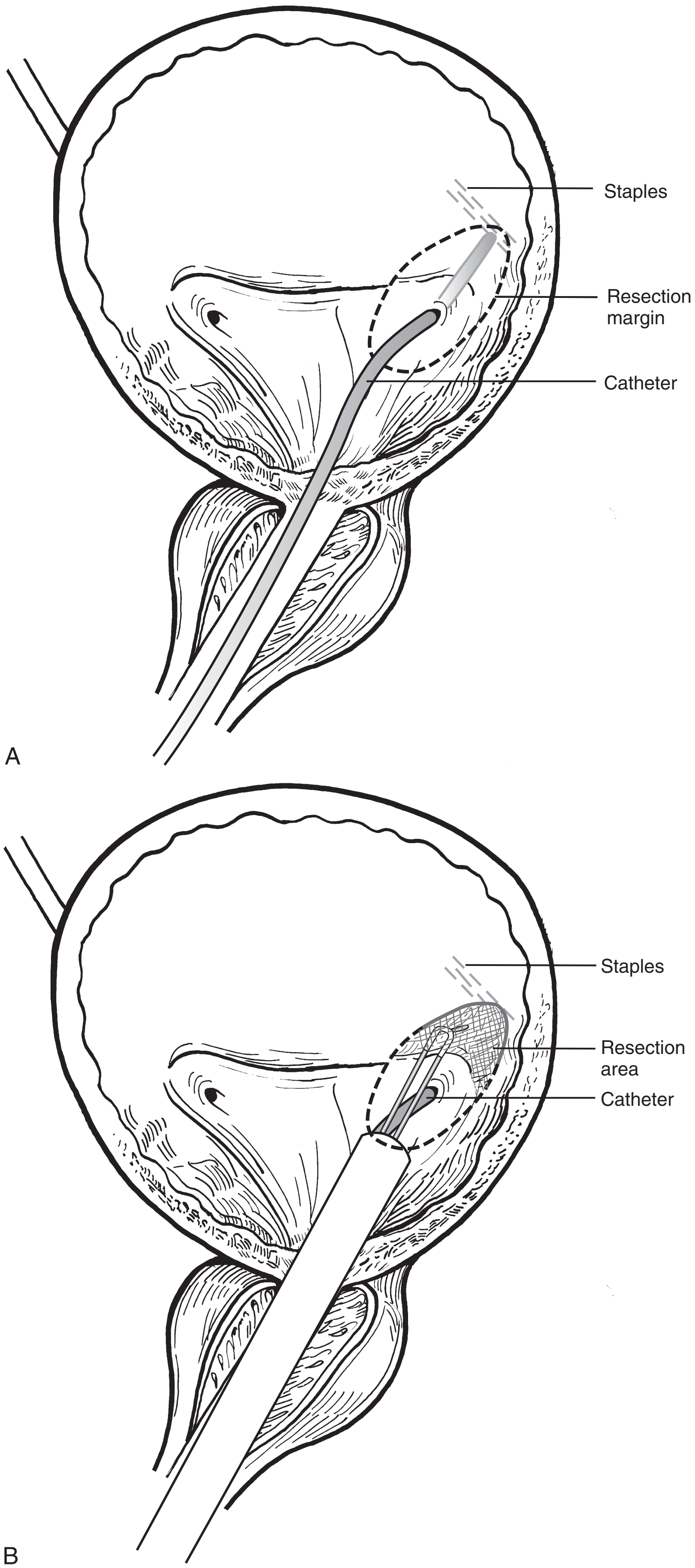

FIGURE 8–7. Endoscopic unroofing and fulguration of the intravesical tunnel following extravesical stapling of the bladder cuff. *A,* A whistle-tip catheter is introduced via the cystoscope into the ureteral orifice and advanced to the occluding row of staples. *B,* The Collins electrocautery knife mounted on a 24-French resectoscope is used to incise the intravesical tunnel over the introduced catheter.

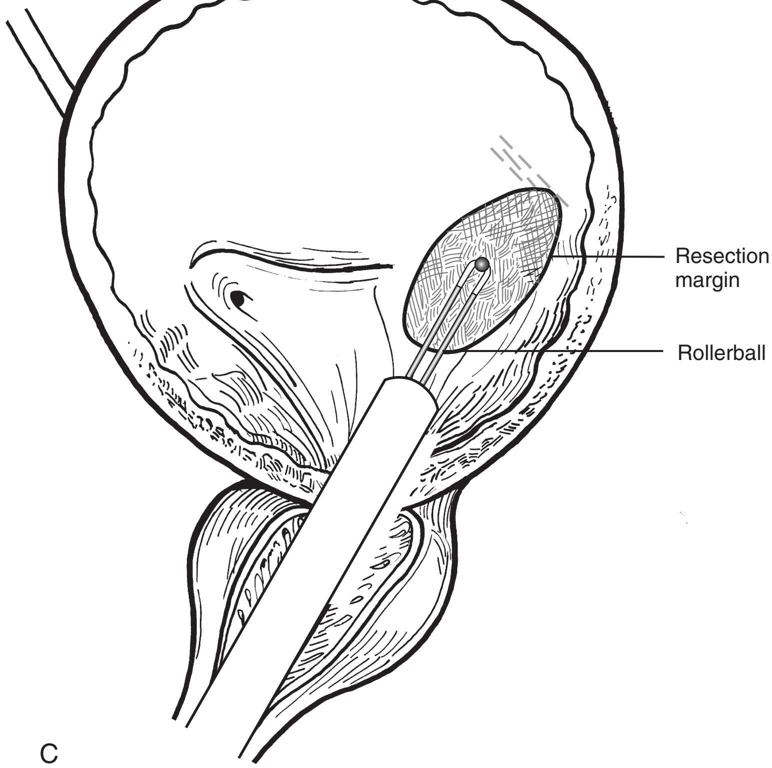

FIGURE 8–7, cont'd. *C,* The whistle-tip catheter has been removed and the rollerball electrode is used to fulgurate the edges and base of the incised intravesical ureter.

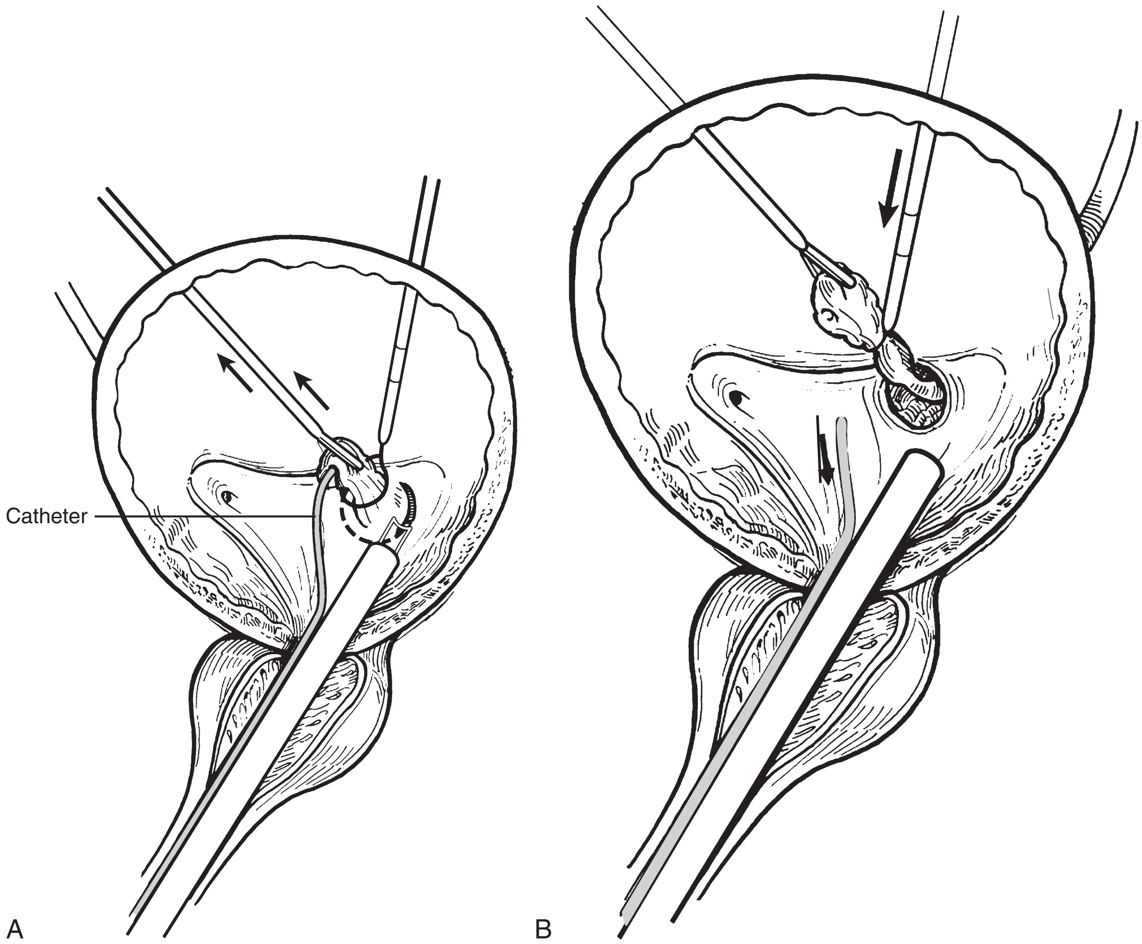

FIGURE 8–8. Transvesical laparoendoscopic management of the distal ureter and associated bladder cuff. *A,* Small transvesical laparoscopic ports are used to position an EndoLoop over the affected ureter through which an open-ended catheter has been inserted. A laparoscopic grasper is used to retract the ureter medially as a Collins knife mounted on a 24-French resectoscope begins incision of the bladder cuff. *B,* The open-ended catheter is withdrawn and the EndoLoop is tightened on the mobilized ureter to prevent efflux of tumor cells.

Endoscopic Release "Pluck"

Perform an initial endoscopic release of the ureter with or without a surrounding cuff of bladder using the Collins knife mounted on a resectoscope. Continue the dissection circumferentially until the perivesical fat is visualized in all areas. Before release, insert a floppy-tipped wire and catheter via the cystoscope into the distal ureter to facilitate the dissection, if needed. Use a 7-French 11.5-mm ureteral occlusion balloon catheter to prevent the efflux of tumor cells as previously described. During the endoscopic portion of the procedure, it is critical to minimize irrigation to reduce the amount of extravasation and the potential for developing a large retroperitoneal collection and resultant hyponatremia.[11] Continue the dissection until the ureter is completely free of all detrusor attachments, then remove the ureteral catheter and insert a 24-French Foley catheter. If an occlusion balloon catheter is used, secure it to the Foley catheter and leave it in place during repositioning.

Then place the patient in a flank position and perform a hand-assisted laparoscopic nephrectomy as previously described. As dissection of the ureter approaches the ureterovesical junction, place gentle cephalad traction on the ureter and divide all small feeding vessels until the ureter is completely free of the bladder and the specimen is removed. Clip the ureter as soon as it is identified to prevent extrusion of tumor cells. If an occlusion balloon catheter is present, clip the ureter directly across the catheter-containing ureter, if needed. Then transect the occlusion catheter as it exits the bladder and deliver its distal segment with the specimen while withdrawing the proximal end from the urethra.

Wong and Leveillee[10] described a similar endoscopic "pluck" technique performed following completion of the hand-assisted laparoscopic nephrectomy that takes advantage of the introduced hand and does not require repositioning. In this approach, place the patient in a modified dorsal lithotomy position with the side of pathology elevated 30 degrees. Support the patient in position using a beanbag and an axillary roll. Secure the legs in low Allen stirrups to provide simultaneous urethral access, and place the ipsilateral arm in an abducted internally rotated position on an arm support. Prep the genitals into the surgical field, and insert a sterile Foley catheter. Then perform a hand-assisted laparoscopic nephrectomy as outlined earlier with early clipping of the ureter to prevent extrusion of tumor cells. After distal dissection of the ureter to the level of the ureterovesical junction, introduce the 24-French resectoscope with the attached Collins knife, and release the ureteral orifice and surrounding bladder cuff as described earlier. Use the introduced hand to gently retract and present the detrusor attachments as the dissection proceeds until the specimen is completely freed and delivered via the hand-assist port. Do not close the bladder defect, reinsert the Foley catheter, and close the ports as outlined later.

Exit the Abdomen and Close the Port Site

Position a 15-French round Davol drain in the ipsilateral pelvis and bring it out through a lateral port site for procedures where the bladder is left open. Close the fascial incision at each of the 10/12-mm port sites using a grasping needle closure device such as the Carter-Thomason (Inlet Medical, Eden Prairie, MN) and a 0 Vicryl suture. Use the introduced hand to assist in transferring the suture from the jaws of the needle grasper after it punctures the fascia.

Perform complete inspection of the dissection site under standard (15 mm Hg) and low (5 mm Hg) insufflation pressures. Use the harmonic shears and electrocautery to obtain hemostasis. Apply a small sheet of surgical cellulose, if needed, to the area of the transected hilar stumps and along the edge of the retained adrenal gland to facilitate hemostasis in these regions. Remove the 5-mm ports, if present, under direct vision, followed by the 10/12-mm trocars, which are withdrawn with the hand protecting the viscera and omentum from becoming entrapped in the closure.

Thoroughly decompress the abdomen, and then position the omentum over the bowel beneath the hand-port incision. Close the peritoneum at this site as a separate layer to prevent subfascial herniations using a running 2-0 chromic suture and use a 1-PDS suture on the fascia. Irrigate the subcutaneous tissues of the hand-assist incision and port sites with antibiotic solution, and reapproximate the skin using a running subcuticular stitch and Steri-Strips. Apply a sterile island or gauze dressing to the hand incision and use Band-Aids or gauze and Tegaderm to cover the port sites.

POSTOPERATIVE MANAGEMENT

Patients are encouraged to begin ambulation on the evening of their surgery. A clear liquid diet is begun once active bowel sounds are present, typically the morning after surgery, and is advanced as tolerated. Pain management consists of intravenous narcotic as needed, which is converted to oral narcotic once bowel function returns. The drain, if present, is continued until outputs average less than 30 mL/8-hour shift on two consecutive shifts. If questions exist regarding a persistent urine leak, the drain fluid can be sent for a creatinine level, which should correspond with serum levels when no leak is present. The drain can be left in place longer if the drain fluid creatinine is elevated. Patients are discharged to home when tolerating a regular diet with adequate pain control on oral medication; typically, this occurs on postoperative day 2 or 3. A Foley catheter is left in place for approximately 7 to 10 days for procedures where the bladder is left open. An office-based cystogram can be performed on the day of planned removal to confirm lack of extravasation. In patients who had the bladder cuff secured using a stapling device, the Foley catheter is removed on the day of discharge. Cancer follow-up including office-based cystoscopy, chest radiographs, and abdominal/pelvic imaging are performed identical to that for patients undergoing open nephroureterectomy.

COMPLICATIONS

In a prospective comparison between hand-assisted laparoscopic and open surgical nephroureterectomy, Seifman and associates[4] reported 19% major and 19% minor complication rates of hand-assisted laparoscopic nephroureterectomy compared with 45% and 27%, respectively, for its open counterpart. Minor complications included ileus, wound infection, and urethral catheter obstruction, and major complications included two patients with respiratory failure requiring reintubation and one death due to cardiac arrhythmia on postoperative day 27. In their series of 22 hand-assisted laparoscopic nephroureterectomies, Stifelman and colleagues[5] reported no intraoperative

and only one postoperative complication. This consisted of a patient who developed thrombophlebitis of the right external jugular vein due to intravenous line placement.

Landman and associates[13] compared 16 hand-assisted with 11 standard laparoscopic nephroureterectomies and reported complication rates of 31% and 45%, respectively. A single patient (6%) in the hand-assist group was converted to an open procedure due to failure to progress. Postoperative complications in one patient undergoing hand-assist laparoscopic nephroureterectomy included respiratory failure due to pneumonia with eventual myocardial infarction and sudden death 3 weeks following surgery. Other postoperative complications included two patients with ileus, one of whom also developed a pneumonia, and another patient who required a postoperative transfusion of 2 units of packed red blood cells.

Urinary extravasation has been reported for both hand-assisted and standard laparoscopic surgery and usually can be managed with prolonged catheterization and percutaneous drain placement if necessary.[8,11] Gill and colleagues[11] reported draining the retroperitoneum through a Gibson incision in a patient in whom a transvesical laparoscopic distal ureterectomy with bladder cuff excision was performed first followed by a standard laparoscopic nephroureterectomy. This patient also had the resultant complication of fluid absorption and hyponatremia.

Pelvic and retroperitoneal tumor seeding have been reported for open and laparoscopic nephroureterectomy and is thought to be an increased risk when an initial endoscopic "pluck" technique is used.[8] High tumor grade and stage were the common features of three cases of retroperitoneal tumor recurrence following laparoscopic nephroureterectomy in the series from Washington University.[8]

SUMMARY

The hand-assist device can serve as a useful adjunct when performing a laparoscopic nephroureterectomy. A number of techniques are available for managing the distal ureter, and, in part, the approach is determined by the grade and location of the patient's cancer in addition to the surgeon's preference.

Tips and Tricks

- Insertion of instruments directly through the matrix of the GelPort hand-assist device often obviates the need for insertion of an additional port when performing the distal ureteral dissection.
- It is almost always necessary to transect the superior vesical artery to gain adequate entrance into the intravesical tunnel when the Endo-GIA stapler is going to be applied to the ureter and attached bladder cuff.
- An open-ended, whistle-tip, or dilating balloon catheter can be inserted into the intravesical tunnel to facilitate endoscopic unroofing. It is not necessary to use an occluding balloon if the nephrectomy portion of the operation is performed first and a clip is placed on the proximal ureter.
- Irrigation should be kept to a minimum when performing an initial endoscopic release of the bladder cuff and distal ureter to prevent significant retroperitoneal extravasation and absorption.

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CHAPTER 9

Laparoscopic Partial Nephrectomy

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Due, in part, to increased use of imaging modalities, the incidence of incidental renal cell carcinoma has increased over the past 10 years.[1] Surgical resection remains the gold standard treatment for renal cell carcinoma but is no longer limited to open total nephrectomy. Partial nephrectomy has been used to treat renal cell carcinoma with oncologic outcomes comparable to those of open radical nephrectomy in select groups of patients.[2] Likewise, laparoscopic partial nephrectomy has become a common treatment modality for select patients, again with favorable oncologic outcomes.[3]

Laparoscopic partial nephrectomy is a procedure that has evolved significantly since 1992 when Clayman and colleagues[4] performed the first procedure in a patient with benign disease. The benefits of such an approach were marked improvement in the postoperative course and the period of convalescence compared with open surgery. Currently, its indications have expanded to include malignancy. As they were in the beginning, the key principles for the successful application of this procedure are the same as in open surgery: secure vascular control, limited renal ischemia, and excellent hemostasis.

INDICATIONS AND CONTRAINDICATIONS

In general, absolute indications for partial nephrectomy include surgical lesions in solitary kidneys or in patients with bilateral renal lesions. Relative indications include renal lesions associated with hereditary syndromes, such as von Hippel–Lindau syndrome, hereditary papillary renal cell carcinoma, or Birt-Hogg-Dubé syndrome, in which there is a risk of future development of ipsilateral or contralateral lesions. Relative indications also exist for patients with unilateral renal lesions with risk of future compromise to the contralateral kidney, such as hypertension and diabetes. Partial nephrectomy for sporadic, unilateral, localized lesions in patients with a normal contralateral kidney is considered an elective indication. These indications can be applied to laparoscopic partial nephrectomy.

Contraindications to partial nephrectomy include renal vein or inferior vena cava thrombus, massive tumor size, and local tumor invasion. Relative contraindications include lymphadenopathy and bleeding diathesis. Although there is no absolute size criterion for partial nephrectomy, it has been shown that tumors less than 4 cm have a decreased recurrence risk and overall survival advantage compared with tumors larger than 4 cm.[5]

PATIENT PREOPERATIVE EVALUATION AND PREPARATION

Before performing laparoscopic partial nephrectomy, take a detailed history and physical examination. The anesthesiologist sees the patient for preoperative evaluation and clearance for surgery. The laboratory evaluation includes urinalysis and routine serum chemistries, including creatinine and liver function tests. Depending on the site and size of the tumor, type and screen or type and cross-match the patient's blood for possible intraoperative transfusion. Standard radiographic imaging includes abdominal computed tomography (CT), with or without three-dimensional reconstruction, depending on the size and location of the tumor. Obtain other imaging studies to exclude metastases, such as chest plain films or CT, bone scan, head CT, or magnetic resonance imaging, as clinically indicated. Typically, administer perioperative antibiotics, routinely a first-generation cephalosporin, approximately 30 minutes before the initial incision.

All patients undergo mechanical bowel preparation before laparoscopy. In case of inadvertent bowel injury, this allows for immediate primary repair. This also results in bowel decompression, improving visualization during an intraperitoneal approach. Proper hydration during the prep is essential because it has important intraoperative and postoperative clinical implications. Euvolemia assists with blood pressure maintenance during surgery because the pneumoperitoneum typically decreases venous return. In addition, euvolemia offers a renoprotective effect for both the operative and unaffected kidneys because dehydration predisposes to acute tubular necrosis.

Place a Foley catheter preoperatively, and use deep venous thrombosis prophylaxis (sequential compression devices). Place an orogastric tube for gastrointestinal decompression to maximize the operating space.

OPERATING ROOM CONFIGURATION AND PATIENT POSITIONING

The operating room configuration is dependent on the laparoscopic approach to be used. As is customary, the anesthesia machine is located at the head of the bed and the scrub nurse and sterile instruments are situated opposite the surgeon to facilitate passage of instruments.

For the transperitoneal approach, the surgeon and camera-holding assistant (some prefer to use a robotic camera holder or fixed table camera holder) stand on the side facing the

patient's abdomen, and the viewing monitor is placed opposite them behind the patient. Some surgeons prefer to have an operating assistant stand opposite them. In such a case, the viewing monitor is placed so as to allow unobstructed viewing by the surgeon and camera-holding assistant. Similarly, a second viewing monitor may be placed opposite the operating assistant to the right or left of the surgeon to allow for unobstructed viewing, with care taken to not restrict the surgeon's ability to move. For the retroperitoneal approach, the setup is the same, except that the surgeon and camera holder stand at the patient's back (Fig. 9–1).

The choice of laparoscopic approach (transperitoneal versus retroperitoneal) is largely dependent on tumor position, patient's surgical history, and surgeon preference. The laparoscopic approach chosen will dictate positioning. Posterior or posterolateral tumors are easily approached retroperitoneally, but the transperitoneal approach is often used because it is most familiar to laparoscopists. Anterior or lateral tumors are best approached transperitoneally.

Placing the patient in the lateral decubitus position greatly aids in the dissection by allowing the bowels to fall away from the kidney. Both approaches can be performed at or between 45 and 60 degrees of lateral tilt. However, for a laparoscopic retroperitoneal approach, a full 90-degree tilt allows for easier establishment of the pneumoretroperitoneum. Elevation of the kidney rest with either approach is used by some. However, remember that neuromuscular complications may result from prolonged pressure from the kidney rest. By and large, table flexion is rarely necessary for the transperitoneal approach, but the least degree of flexion that allows adequate separation of the costal margin and iliac crest is often helpful with the retroperitoneal approach.

Not negotiable, however, is the use of padding for all patient pressure points, including the head and neck, axilla, arms, hip joint, knees, and ankles. It is also advisable to provide slight flexion at the joints to prevent inadvertent hyperextension during the case. Some prefer to use a variety of padded armrests for the upper arm. We prefer to manage the upper arm by securing it between eggcrate foam cushions and placing it across the patient's nipple line with a slight upward bend at the elbow. In all cases, secure the patient to the table using a safety belt and/or wide, strong adhesive tape, taking care to protect the skin from tape damage. Before prepping and draping, tilt the table to ensure that the patient is fastened securely (see Fig. 9–1).

TROCAR PLACEMENT

Trocar placement is dependent on the intended laparoscopic approach. For simplicity, we use a three-trocar placement technique for intraperitoneal and retroperitoneal approaches that may be used interchangeably for right- or left-sided approaches, requiring only changes in trocar sizes, depending on the surgeon's preference or hand dominance. For the intraperitoneal approach, place a 10-mm camera trocar at the umbilicus. Place a 10/12-mm working trocar lateral to the rectus abdominis muscle in the midclavicular line, and place a 5-mm trocar in the midline between the xyphoid process and the umbilicus. Place an additional 5-mm trocar cephalad to the aforementioned subxiphoid 5-mm trocar as needed for liver retraction or a 10/12-mm trocar in the midline below the umbilicus for Satinsky clamp placement if not using laparoscopic bulldog clamps. For obese patients, laterally shift the trocars toward the kidney (Fig. 9–2).

For the retroperitoneal approach, place the laparoscope through a 10-mm balloon-tipped trocar located just below the tip of the 12th rib, the site of initial retroperitoneal blunt dissection, after dilating the working space with a balloon. After medial reflection of the peritoneum, place a 5-mm trocar in the anterior axillary line between the iliac crest and the tip of the 11th rib. Posteriorly place a 10/12-mm trocar in the angle between the 12th rib and the spinous musculature. An assistant may place a 5-mm trocar in the upper anterior axillary line as needed (Fig. 9–3).

PROCEDURE

Intraperitoneal Approach

For lesions that extend into the renal collecting system, some recommend cystoscopic placement of an ipsilateral ureteral catheter through which dilute indigo carmine or methylene blue may be injected to facilitate intraoperative identification and repair of collecting system injuries.[6] Others have not found that this improves their ability to detect or manage injuries to the collecting system.[7]

After establishing a pneumoperitoneum via a Veress needle and trocar placement, medially reflect the colon along the white line of Toldt. Entering the retroperitoneal space sufficiently often requires sharp release of the splenorenal or the hepatorenal ligaments, depending on the operative side and location of the lesion. As the colon is reflected, the plane between anterior Gerota's fascia and the posterior mesocolon is developed. Next, identify the psoas muscle, along with the overlying ureter and gonadal vein, which can be traced upward toward the renal hilum. Dissect the renal artery and vein to the extent that a Satinsky or bulldog clamp can be placed easily when needed (Fig. 9–4).

Next, enter Gerota's fascia away from the area of the lesion, and use intraoperative ultrasound to identify the exact tumor location and assess the width and depth of invasion. Once this is known, dissect perirenal fat at least 5 mm away from the lateralmost extent of the lesion to expose the renal capsule (Fig. 9–5). Perform intraoperative ultrasound (US), using a laparoscopic transducer, to determine the depth and margins of the renal tumor, and determine whether additional renal lesions are present (Fig. 9–6). Then score the capsule using electrocautery from monopolar scissors (Fig. 9–7). Clamp the hilum and note the time (Fig. 9–8). Sharply incise the scored line of the renal capsule using cold scissors, and resect the tumor with the assistance of the suction cannula for countertraction and maintenance of a clear operative field (Fig. 9–9). This technique facilitates the proper plane of parenchymal dissection—preventing violation of the tumor capsule—as well as recognition of the renal collecting system. Then introduce a 10-mm EndoCatch (Auto Suture, Norwalk, CT) or other retrieval sac via the 10/12-mm working port, and retrieve the specimen after performing renal reconstruction.

After resection of larger or more centrally located lesions in which collecting system entry has been anticipated, assess for leakage by direct observation of urinary extravasation or by indigo carmine or methylene blue injection into the renal collecting system, if a ureteral catheter was placed at the begin-

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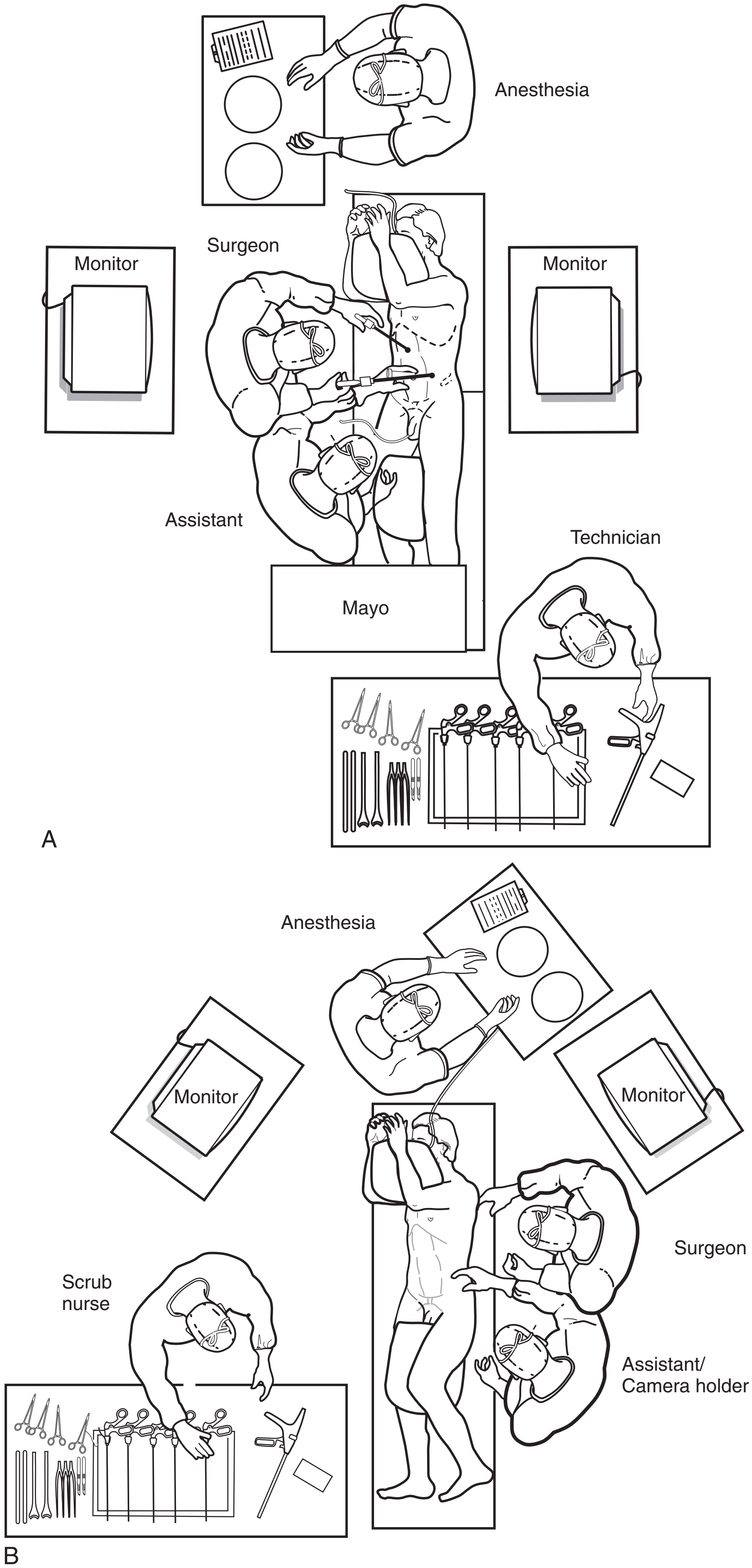

FIGURE 9–1. *A,* Operating room configuration for laparoscopic transperitoneal nephron-sparing surgery. The patient is in a modified lateral position. *B,* Operating room configuration for a laparoscopic retroperitoneal nephron-sparing surgery. The patient is in a full lateral position.

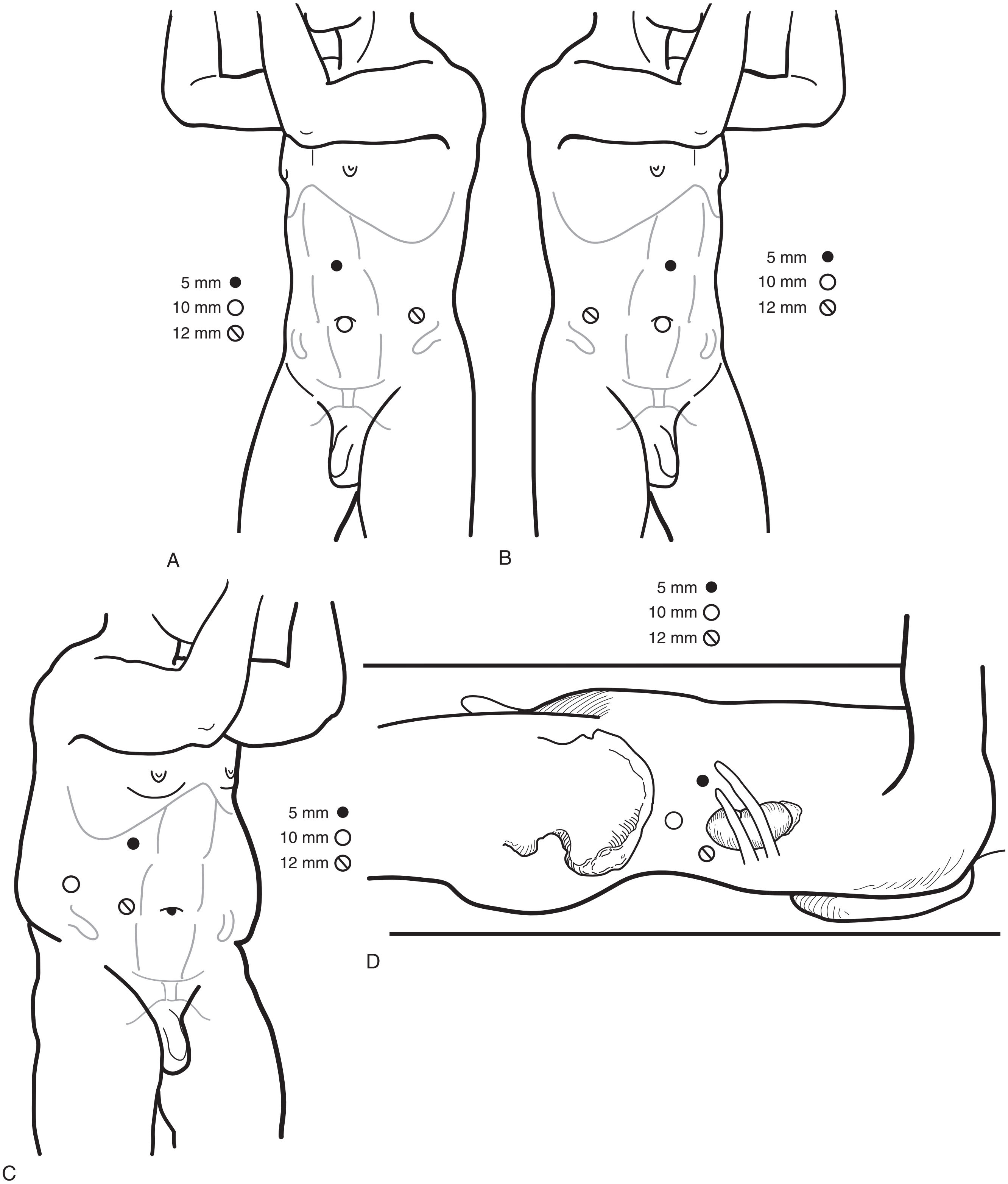

FIGURE 9–2. *A,* Trocar placement for left-sided transperitoneal laparoscopic nephron-sparing surgery. *B,* Trocar placement for right-sided transperitoneal laparoscopic nephron-sparing surgery. *C,* In the obese patient, the entire trocar configuration is shifted so that what would have been the umbilical trocar is in line with the umbilicus but placed lateral to the rectus muscle. *D,* Trocar placement for retroperitoneal laparoscopic nephron-sparing surgery.

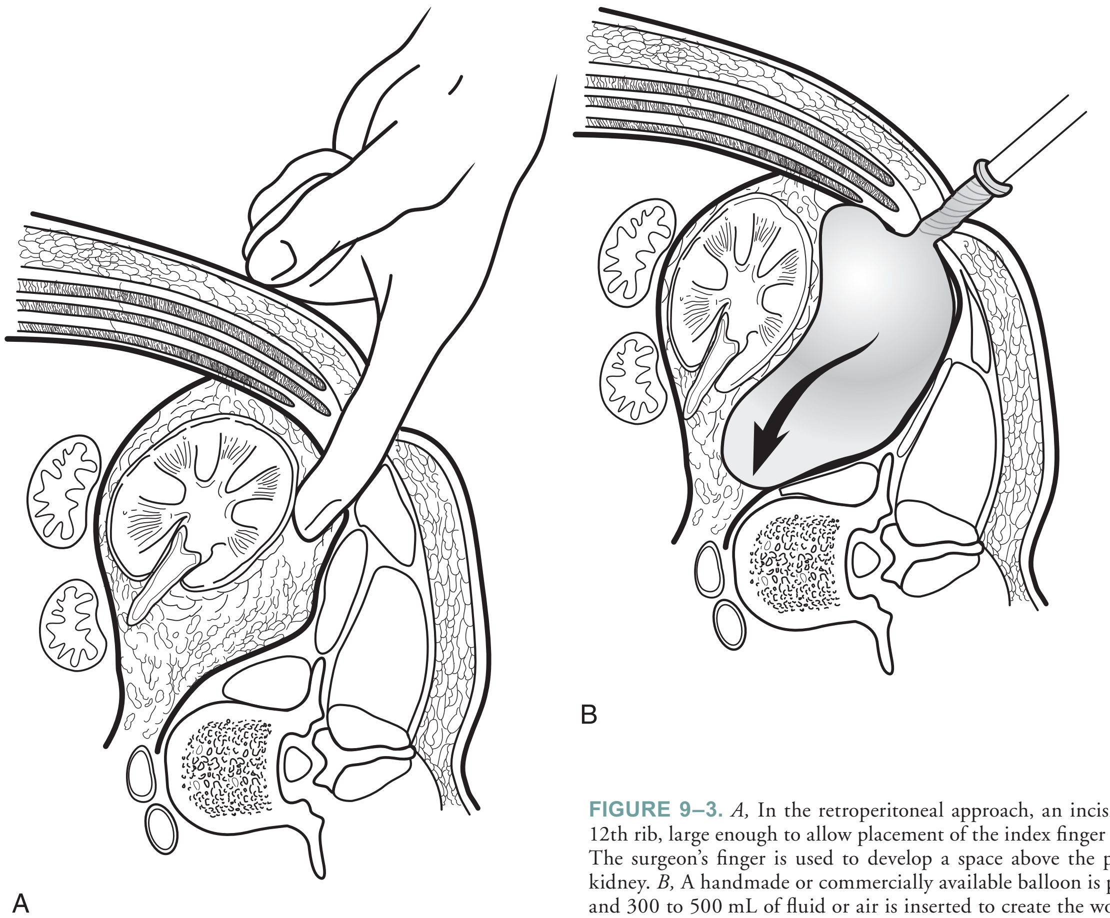

FIGURE 9–3. *A,* In the retroperitoneal approach, an incision is made off the tip of the 12th rib, large enough to allow placement of the index finger into the retroperitoneal space. The surgeon's finger is used to develop a space above the psoas muscle, posterior to the kidney. *B,* A handmade or commercially available balloon is placed posterior to the kidney, and 300 to 500 mL of fluid or air is inserted to create the working space.

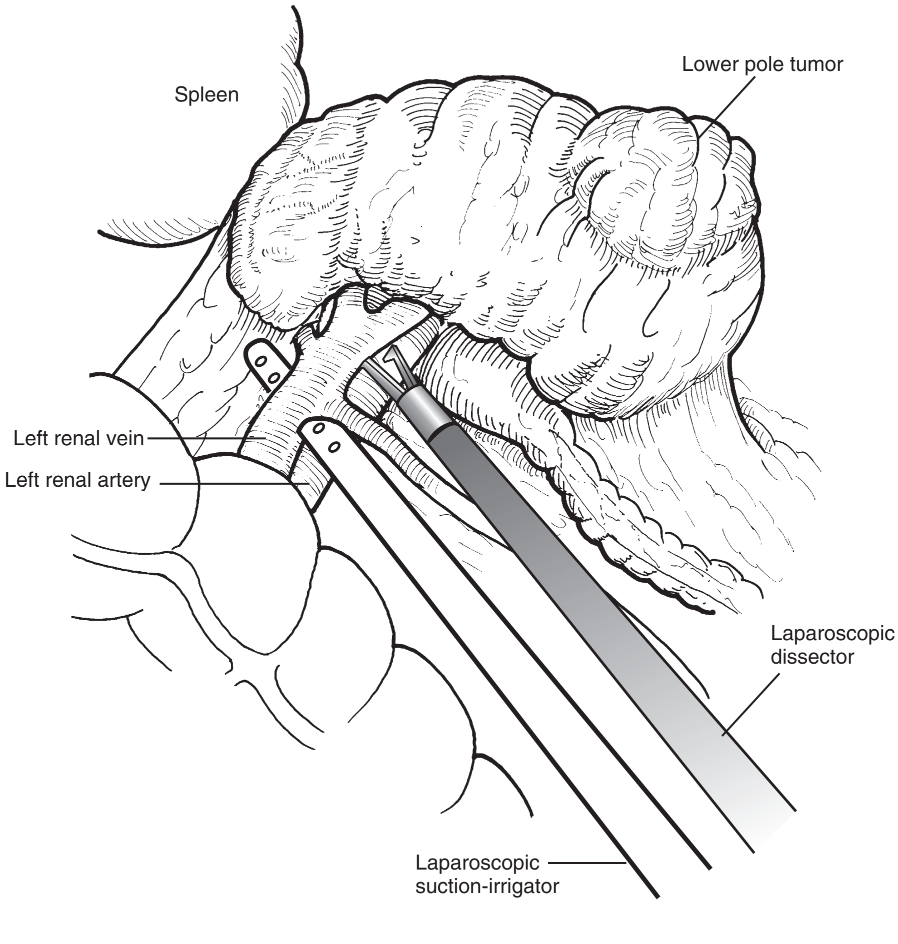

FIGURE 9–4. Careful dissection of the renal artery and renal vein allows complete occlusion and hilar control of the blood vessels to create a bloodless field for dissection of the renal mass.

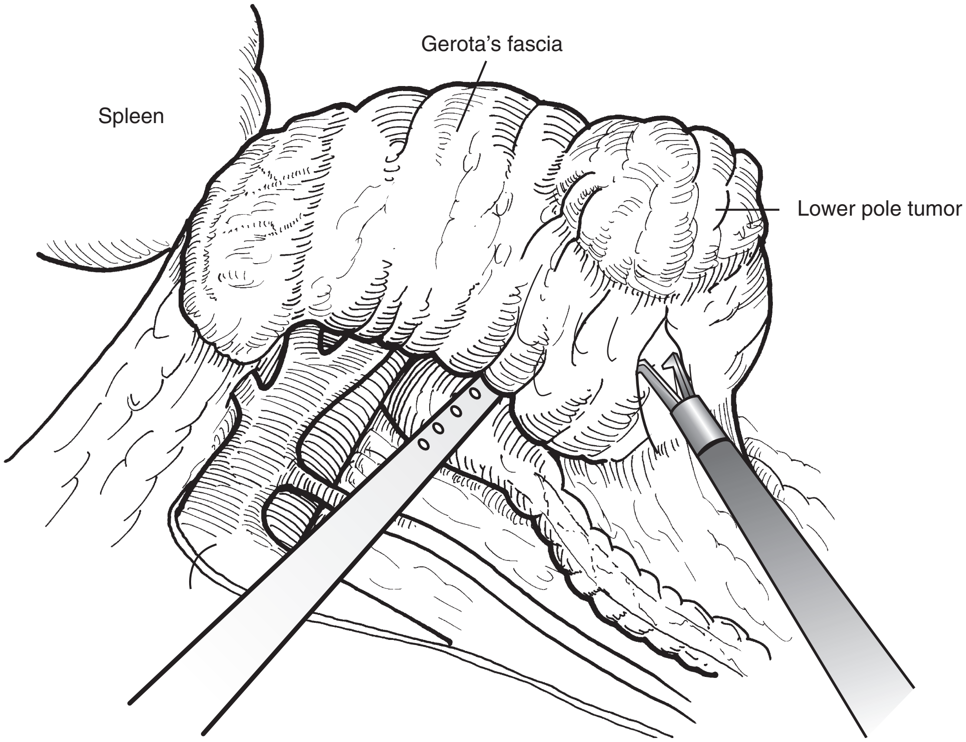

FIGURE 9–5. Gerota's fascia is opened near the renal mass, and the surface of the uninvolved kidney is identified.

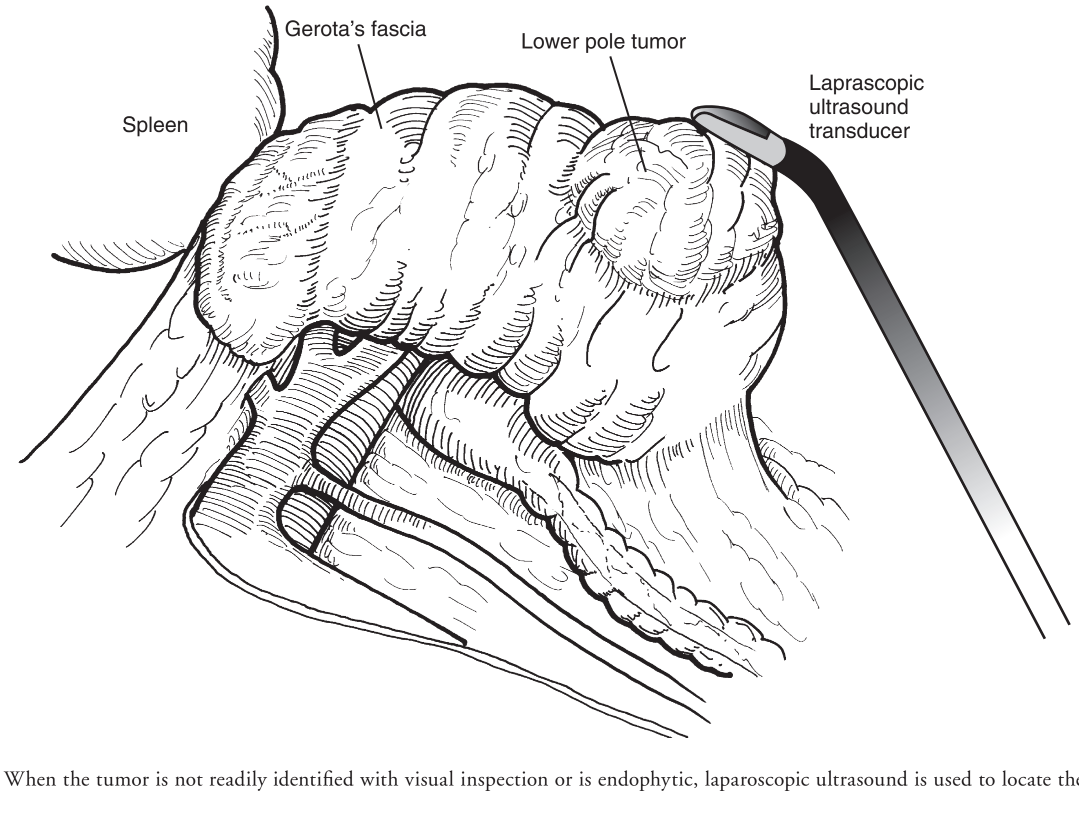

FIGURE 9–6. When the tumor is not readily identified with visual inspection or is endophytic, laparoscopic ultrasound is used to locate the mass.

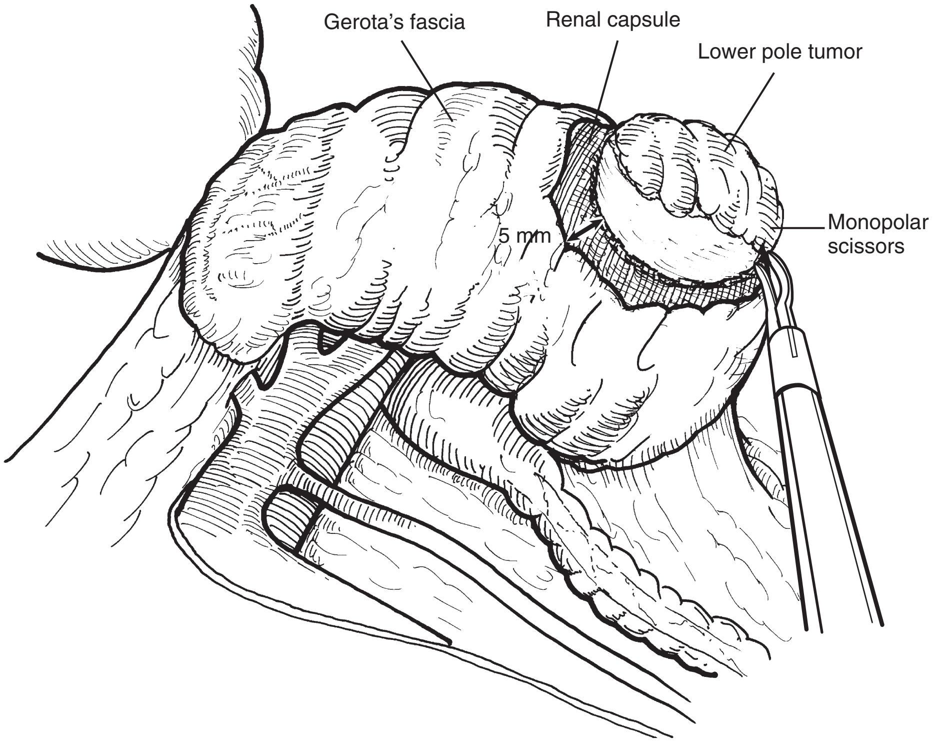

FIGURE 9–7. Electrocautery from closed monopolar scissors is used to score renal parenchyma at least 5 mm from tumor to delineate intended line of dissection.

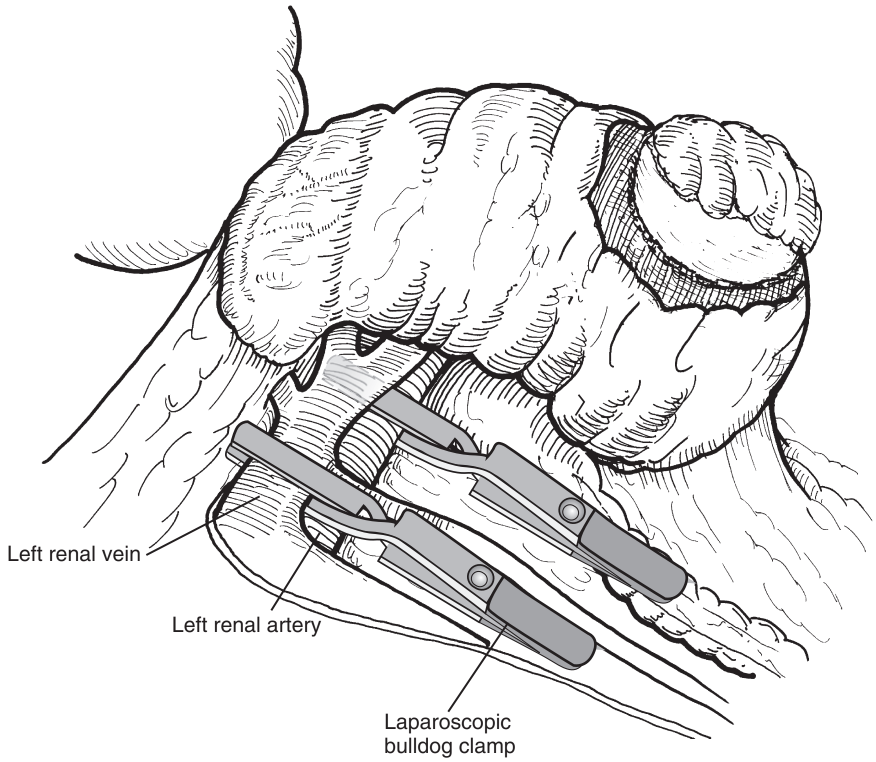

FIGURE 9–8. Vascular clamps are placed individually on both the renal artery and vein, or the renal hilum can be occluded with a vascular clamp inserted through a separate trocar site.

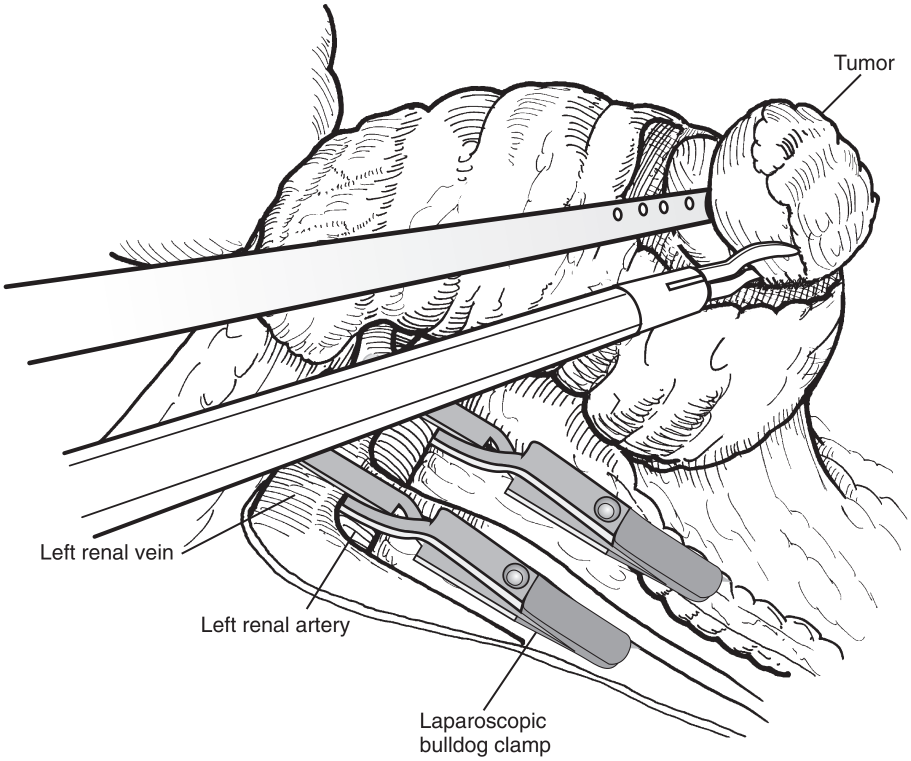

FIGURE 9–9. The irrigator-aspirator tip is used for countertraction and to maintain a bloodless field while cold scissors are used to excise lesion.

ning of the case. If a collecting system violation is noted, oversew it with interrupted 3-0 Vicryl sutures (Fig. 9–10).

Oversew cut arteries or veins that are identified in the renal defect with 3-0 Vicryl sutures. Then fill the renal parenchymal defect with a single or combination of hemostatic agents (FloSeal or Tisseel [Baxter Healthcare Corp., Deerfield, IL], Surgicel [Johnson & Johnson, New Brunswick, NJ], gelfoam and thrombin, and so on) (Fig. 9–11). If Surgicel bolsters are used, place 3-0 Vicryl sutures anchored to the adjacent renal parenchyma across the bolsters to secure them in place and to compress the edges of the renal defect (Fig. 9–12).

Release the vascular clamp and observe the renal defect for hemorrhage. Compression with a mini-lap pad placed through the 12-mm port before hilar clamping may help establish hemostasis. Decrease the pneumoperitoneum to less than 10 mm Hg for 5 to 10 minutes while continuously observing for bleeding. Once adequate hemostasis has been ensured, place a closed suction drain in the paracolic gutter adjacent to the kidney but not overlying the renal defect.

Use a Carter-Thomason closure device with a 0 Vicryl suture to close the 10/12-mm trocar sites under direct laparoscopic vision, ensuring that no vital structures are entrapped. Release CO_2 from the abdomen, and close the skin incisions in a running subcuticular fashion.

Retroperitoneal Approach

Make a 15-mm incision in the area of Petit's triangle, just below the tip of the 12th rib, and extend the dissection downward through the lumbodorsal fascia and into the retroperitoneal space with the aid of a clamp. Bluntly dissect this space with the tip of a finger along the psoas muscle posterior to the kidney. Next, place a balloon dilator through this tract, and, under vision, further expand the retroperitoneal space. Introduce a 10-mm camera via this trocar, and establish a pneumoretroperitoneum of 15 mm Hg. Expand and cinch the trocar cuff to the skin to prevent CO_2 leakage. View pertinent structures for orientation and to exclude entry trauma: the psoas muscle with overlying intact fascia and ureter, inferiorly; intact Gerota's fascia surrounding the kidney, cephalad; and intact peritoneal membrane, anteriorly. Place the other trocars as described previously, and further expand the retroperitoneal space by bluntly sweeping the peritoneum anteriorly (see Fig. 9–3).

Retract the kidney upward and cephalad while bluntly dissecting it off the psoas fascia. The pulsation of the renal artery is then evident and guides the approach to its dissection. Dissect the renal artery and vein to the point of allowing easy placement of bulldog clamps when needed. Next, use intraoperative US to verify the location and extent of the renal lesion. Enter Gerota's fascia away from the area of the lesion, and remove the lesion as described for the intraperitoneal approach after clamping the vessels.

With either laparoscopic approach, minimize warm ischemia time (<30 minutes, not >1 hour) because clamp times within this time period have been shown not to result in long-term renal dysfunction.[8]

POSTOPERATIVE MANAGEMENT

Important immediate postoperative considerations include, but are not limited to, monitoring of vital signs and quantity and content of drain output. Delayed bleeding may occur for up to 30 days after partial nephrectomy[9]; therefore, it is imperative

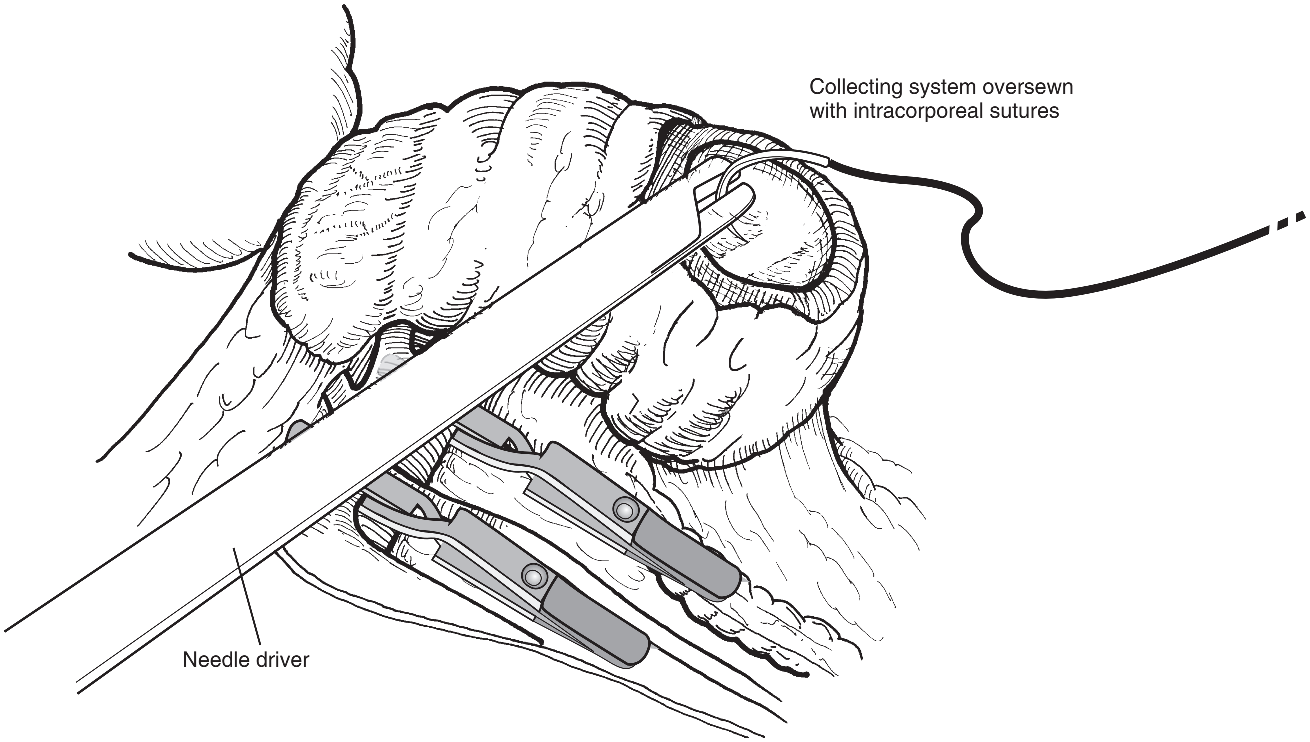

FIGURE 9–10. Entry into the collecting system is common and can usually be seen without assistance. Some surgeons place an open-ended catheter at the beginning of the case and use retrograde injection of methylene blue to identify sites where the collecting system has been transected. Collecting system injury is repaired with 3-0 absorbable suture. The Lapra-Ty clip (Ethicon Endo-Surgery, Cincinnati, OH) can be placed on the end of the suture as a knot, and a second clip is applied to secure the suture.

to keep in mind that bleeding remains at the forefront of potential complications. Continued renal hemorrhage may manifest itself as persistent or copious bloody drain output, hematuria, or unstable vital signs.

We recommend early ambulation to minimize the risk of deep venous thrombosis; however, 24 hours of postoperative bedrest is routinely prescribed by others.[9] Furthermore, we restrict strenuous exercise for at least 1 month to allow adequate healing of the partial nephrectomy bed.

If an orogastric tube or a ureteral catheter has been placed, remove it immediately postoperatively. Allow the Foley catheter to remain overnight. Note drain output volume and whether it increases after Foley catheter removal because this may be an indication of vesicoureteral reflux into a persistent or unrecognized renal collecting system injury.

Monitoring the drain fluid creatinine concentration may help differentiate peritoneal fluid from urine and assist in deciding on drain removal. Remove the drain only when the fluid content is consistent with peritoneal fluid, in color and chemical composition.

COMPLICATIONS

Complications following laparoscopic partial nephrectomy can generally be divided into intraoperative and postoperative categories. The most common intraoperative complication that can be attributed directly to the laparoscopic nature of this technique is hemorrhage, occurring in 3.5% in one of the largest published series.[9] Intraoperative hemorrhage is invariably due to inadequate vascular control technique. Some have found that laparoscopic bulldog clamps, which are often used for the retroperitoneoscopic approach, provide suboptimal vascular occlusion compared with Satinsky clamps. We have not found this to be true, and Satinsky clamps are not infallible. In addition to clamp failure, failure to identify and control multiple renal arteries also may result in intraoperative hemorrhage. If the hemorrhage cannot be controlled quickly, conversion to open surgery is indicated.

Postoperative complications directly attributable to the laparoscopic technique are also typically related to hemorrhage or renal collecting system injury. Postoperative or delayed unprovoked spontaneous hemorrhage from the partial nephrectomy bed has been described as occurring up to 14 days postoperatively and in 6% of patients.[9] Bedrest with spontaneous resolution, segmental arterial embolization, or completion nephrectomy are the usual treatment measures, depending on the severity of hemorrhage.

Renal collecting system injury also occurs intraoperatively,[9] sometimes from necessity to completely excise a large or more centrally located lesion. Such injuries may not be recognized immediately. Aforementioned techniques to identify such injuries are available. Most surgeons recommend immediate closure of large defects, but opinions differ on the need to close smaller ones.

Significant renal collecting system leaks usually manifest perioperatively as persistent drain output consistent with urine. Delayed presentation of unrecognized leaks usually manifests as urinomas, symptomatic or asymptomatic. Management in the perioperative period may consist of collecting system decompression via ipsilateral ureteral stenting and/or Foley catheter replacement or simple prolongation of the drainage

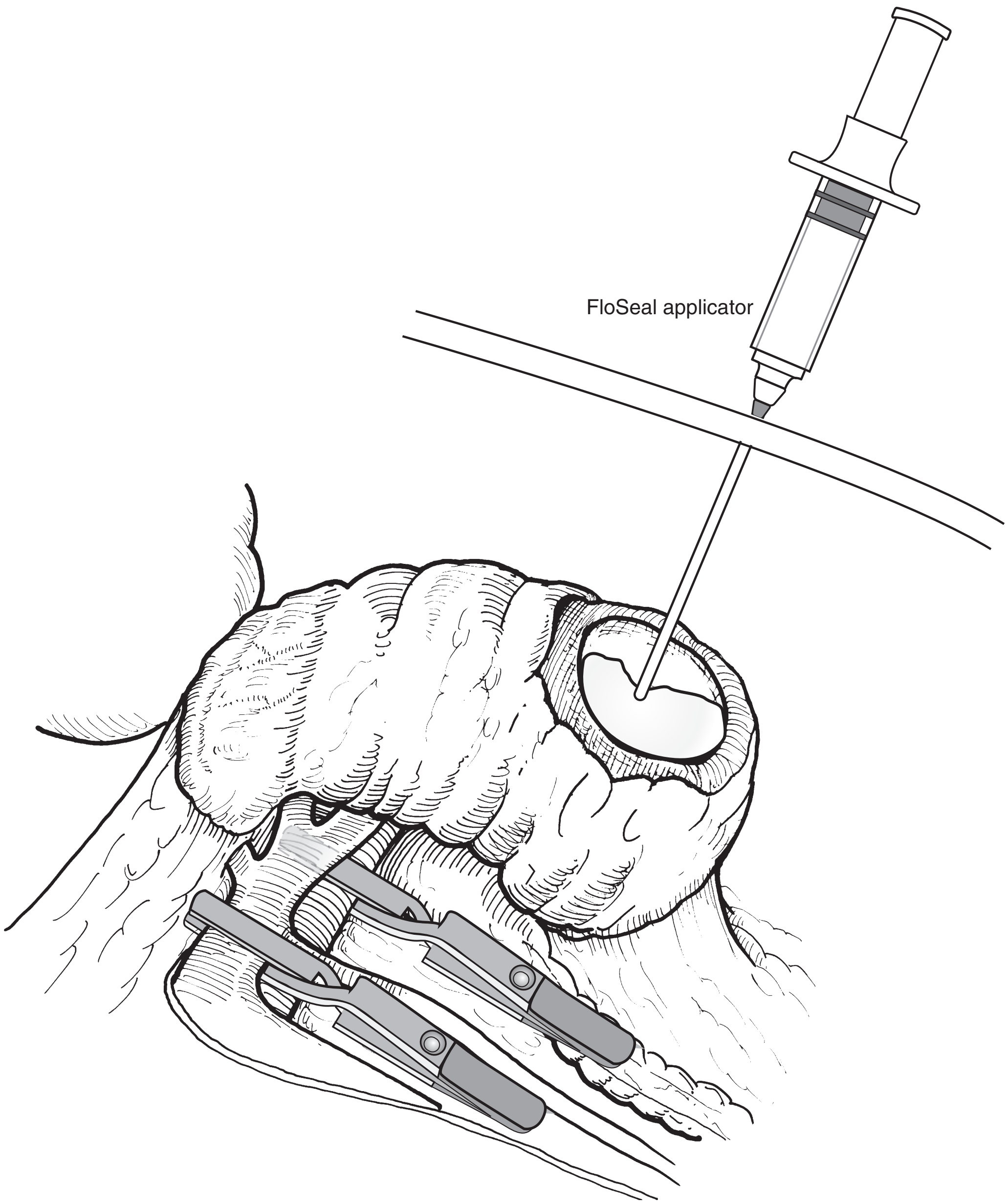

FIGURE 9–11. Hemostatic and sealing fibrin product is applied to the surface of the kidney using a laparoscopic applicator through a trocar near the kidney.

period. Urinomas may be managed by percutaneous drainage, by observation with ureteral stenting, or by observation alone, depending on size and symptomatology.

Other less commonly occurring serious complications include ureteral injury, renal dysfunction, and vascular injuries.

SUMMARY

Technological advances have allowed complex laparoscopic surgery to be performed by urologic surgeons. Laparoscopic partial nephrectomy, which combines both extirpation and renal reconstruction, emulates the open surgical procedure. This is true for both the transperitoneal and retroperitoneal approach. As our field tries to improve the care we provide for patients with renal masses, laparoscopic partial nephrectomy offers these patients a sound oncologic treatment that causes less pain and suffering than is associated with open renal surgery.

Tips and Tricks

- For obese patients, it is often helpful to shift all trocar positions laterally to place them closer to the kidney. This often obviates the need for extra-long instrumentation and for placing undue torque on the trocars with upward retraction. Care should be taken to avoid injuring the epigastric vessels.
- Grasping Gerota's fascia with a Debakey forceps and providing careful upward retraction of the kidney often facilitate hilar identification and dissection.
- Use of Lapra-Ty clips (Ethicon Endo-Surgery, Cincinnati, OH) on each end of sutures decreases warm ischemia time by obviating need for laparoscopic suturing.

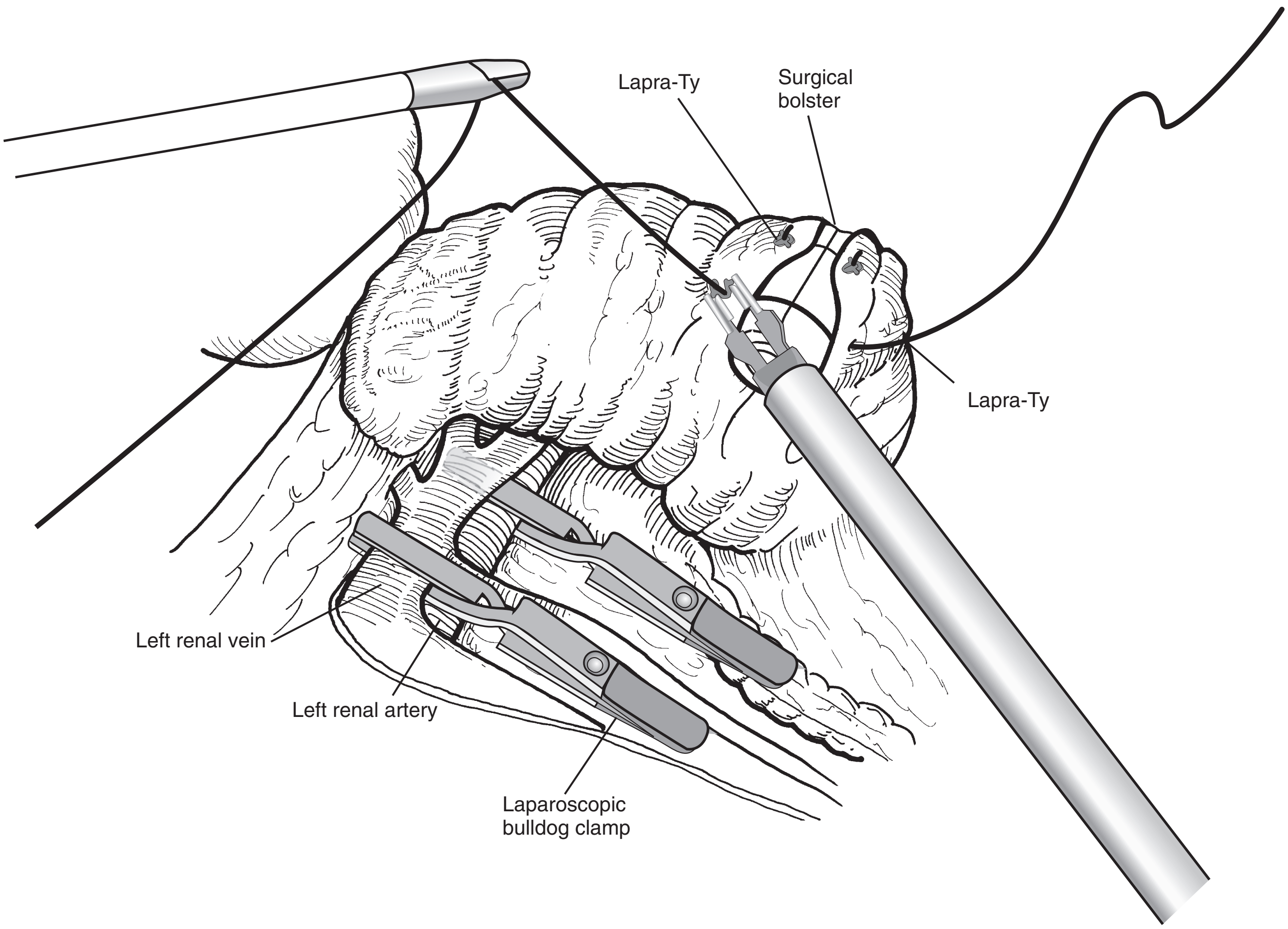

FIGURE 9–12. Hemostatic bolster can be formed by rolling Surgicel, tying each end with an absorbable suture, and placing it in the kidney defect. For large resections, two or more of these bolsters may be necessary. The kidney defect is then approximated with absorbable suture passed approximately 1 cm from the edge of the renal capsule. Lapra-Ty clips can be used to secure both ends of the suture. However, the surgeon must guard against excessive tension on the suture, which can cause the Lapra-Ty to pull through the renal capsule into the kidney.

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CHAPTER 10

Laparoscopic Nephroureterectomy

C. William Schwab II
Thomas W. Jarrett

Transitional cell carcinoma of the upper urinary tract comprises 5% of all urothelial tumors and 5% to 10% of renal tumors. Such tumors have a propensity for ipsilateral recurrence and are classically managed with the surgical removal of the ipsilateral kidney, ureter, and surrounding bladder cuff.[1] The standard open nephroureterectomy is performed through a single large incision or two separate incisions and is associated with significant morbidity and a substantial period of convalescence.

In an effort to reduce the invasiveness of the procedure, the technology and innovation of laparoscopic nephrectomy were translated to laparoscopic nephroureterectomy, first performed at Washington University in 1991.[2] Studies have demonstrated this procedure to have reduced morbidity while providing equivalent oncologic control.[3–6] There have been debates over the various approaches: transperitoneal, retroperitoneal, and hand-assisted. No single approach has shown an advantage, and all show decreased morbidity compared with the open counterpart. The approach chosen depends largely on patient factors and surgeon experience.

Controversy continues regarding the optimal approach to and management of the distal ureter and surrounding bladder cuff. The ideal technique would allow reproducible oncologic control paralleling that of open surgery with a minimum degree of invasiveness, complexity, and required operative time. Several techniques have been described using a variety of endoscopic, laparoscopic, and open approaches. Larger series with intermediate and long-term follow-up are beginning to demonstrate differences in local and retroperitoneal recurrence rates between the various techniques.[5–10]

This chapter describes the transperitoneal approach and several accepted surgical techniques for the distal ureter, including the following:

1. Open dissection and excision of distal ureter and bladder cuff
2. Transvesical laparoscopic technique
3. Modified pluck technique
4. Ureteral unroofing technique

INDICATIONS AND CONTRAINDICATIONS

The indications for laparoscopic-assisted nephroureterectomy remain the same as those for open nephroureterectomy. Transitional cell carcinoma of the renal collecting system or ureter is the most commonly encountered indication. Occasionally, benign conditions or nonfunctioning kidneys warrant removal of the entire ipsilateral upper urinary tract.

The only absolute contraindication to laparoscopic-assisted nephroureterectomy is an uncorrected bleeding diathesis. Relative contraindications include situations that may be more challenging for the inexperienced laparoscopist, including the presence of concomitant inflammatory conditions such as tuberculosis or xanthogranulomatous pyelonephritis and patients with a history of ipsilateral renal surgery or extensive intraperitoneal surgery.

Consider kidney-sparing surgery for patients with low-grade, low-stage disease at risk of renal failure following removal of a renal unit, with a single kidney, with bilateral disease, and with Balkan nephropathy.

PATIENT PREOPERATIVE EVALUATION AND PREPARATION

Preoperatively establish the diagnosis of transitional cell carcinoma of the upper tracts in a manner similar to that for open surgery (Fig. 10–1). Confirm upper tract abnormalities or filling defects with ipsilateral cytologic or ureteroscopic evaluation with direct biopsy or localized cytology at the lesions. Completely evaluate to identify the presence of multiple or bilateral tumors.

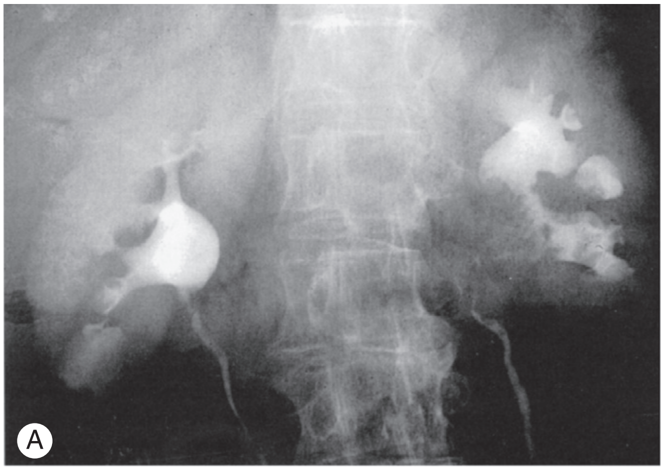
Staging evaluation includes radiographic evaluation of the chest and cross-sectional imaging of the abdomen and pelvis. Obtain standard laboratory serum studies, including liver function tests. Perform a postoperative nephrologic evaluation on patients with limited renal reserve if postoperative renal failure ensues.

Obtain a preoperative urine culture and, if positive, treat it appropriately. Patients maintain a clear liquid diet for 24 hours preoperatively, and they may do a mild mechanical bowel prep the night of surgery. Blood typing and cross-matching and preoperative antibiotic prophylaxis are routine.

OPERATING ROOM CONFIGURATION AND PATIENT POSITIONING

Laparoscopic-assisted nephroureterectomy has two broad objectives. Dissect and isolate the kidney and ureter distal to the pelvis, then remove an intact specimen for exact pathologic staging (dissection of the distal ureter and bladder cuff is one way to do this). Proper positioning optimizes both portions of the procedure, regardless of the technique chosen to manage the distal cuff because intraoperative repositioning without repeat prepping is feasible.

A modified flank/torque position allows intraoperative repositioning of the patient from a flank position, for the



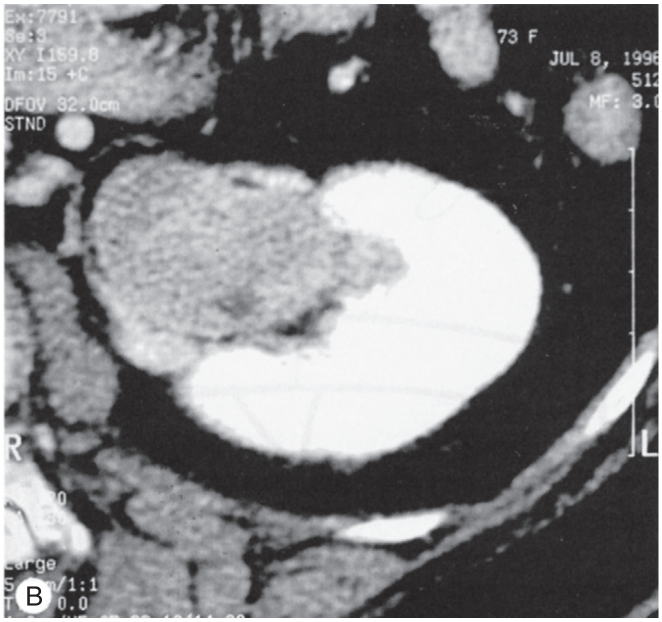


FIGURE 10–1. *A,* Intravenous pyelogram showing large filling defect in the left renal pelvis. *B,* Computed tomography scan confirms mass in the left renal pelvis

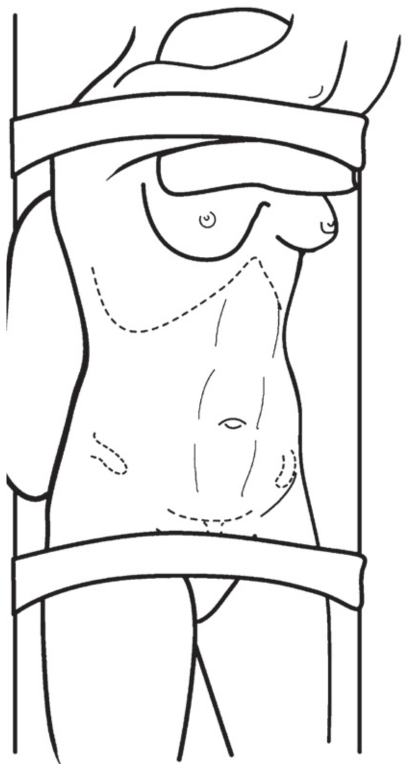


FIGURE 10–2. For laparoscopic nephroureterectomy, the patient is placed in the supine position with the ipsilateral arm across the chest. The patient is secured to the table and may be rotated during the case to the contralateral side.

nephrectomy portion, to a supine position, for the distal ureterectomy portion, without repeat prepping. Bump up the ipsilateral hip, flank, and shoulder to approximately 20 degrees and bring the ipsilateral arm across the table and either place it on a padded arm board or flex it in front of the patient's face on a pillow (Fig. 10–2). An axillary roll is not necessary, but carefully pad pressure points. Carefully fix the patient to the bed with wide cloth tape at the shoulders, hips, and lower extremities. Do not flex the table and do not use the kidney bridge. Rotate the bed to ensure the patient's immobility during the procedure. Widely prep the patient and drape to include the flank and the urethra. Place a Foley catheter on the field before beginning. If the procedure starts with the laparoscopic dissection of the kidney and ureter, stand with the assistant on the side contralateral to the tumor (Fig. 10–3).

TROCAR PLACEMENT

Generally, use a transperitoneal, three-port approach; add a fourth port if retraction of liver, spleen, colon, and kidney become necessary. Trocar position depends mainly on the patient's body habitus (Fig. 10–4). Insufflate the abdomen following Veress needle placement in the umbilicus. For patients with prior midline abdominal surgery, shift needle placement lateral to the rectus at the level of the umbilicus. Place a 10/12-mm trocar with a visual obturator through the umbilicus, into the abdomen, under direct vision. Place a second 10/12-mm trocar at the level of the umbilicus just lateral to the rectus muscle. Place a 5-mm trocar in the midline between the umbilicus and the xiphoid process.

For obese patients, placement in the modified flank position creates a disproportionate shift in the pannus such that trocars placed at the umbilicus will actually enter the peritoneum below the midline and farther away from the retroperitoneum. A shift in trocar placement, lateral to the rectus abdominis, allows for improved visualization and working distances.[11]

During the nephrectomy portion of the procedure, situate the camera in the umbilical port and operate through the superior midline and lateral trocar sites. As the dissection continues, place additional 2- or 5-mm trocars as necessary to aid in retraction or dissection. Use a midline port placed just cephalad to the upper port to retract the gallbladder and liver for right-sided lesions. Use a port in the anterior axillary line or lower midline to aid with lateral retraction of the colon (Fig. 10–5).

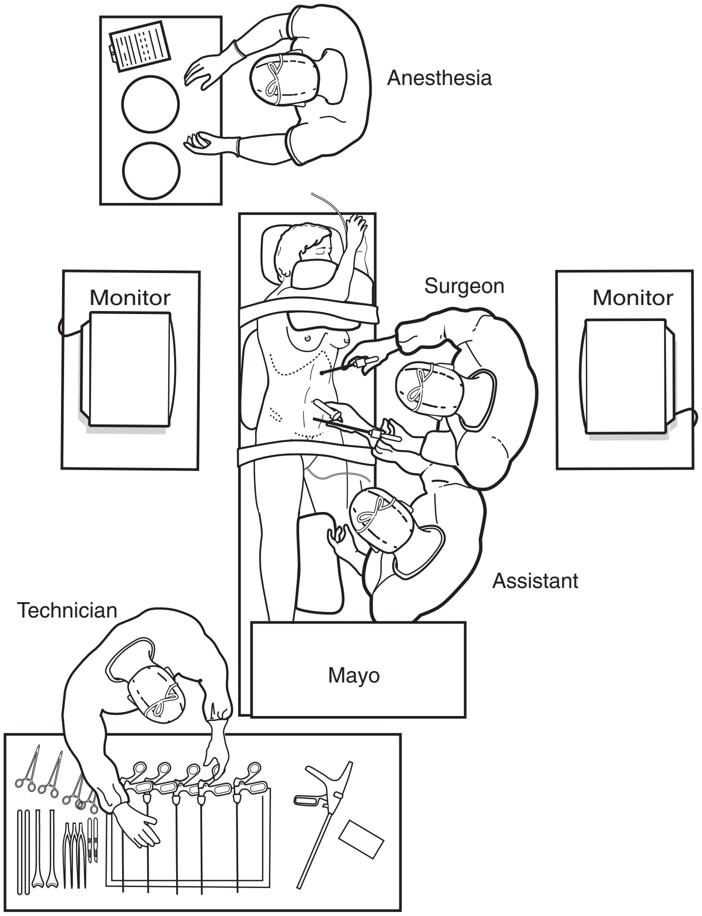


FIGURE 10–3. The surgeon and assistant stand on the contralateral side of the table with the scrub person at the foot of the table.

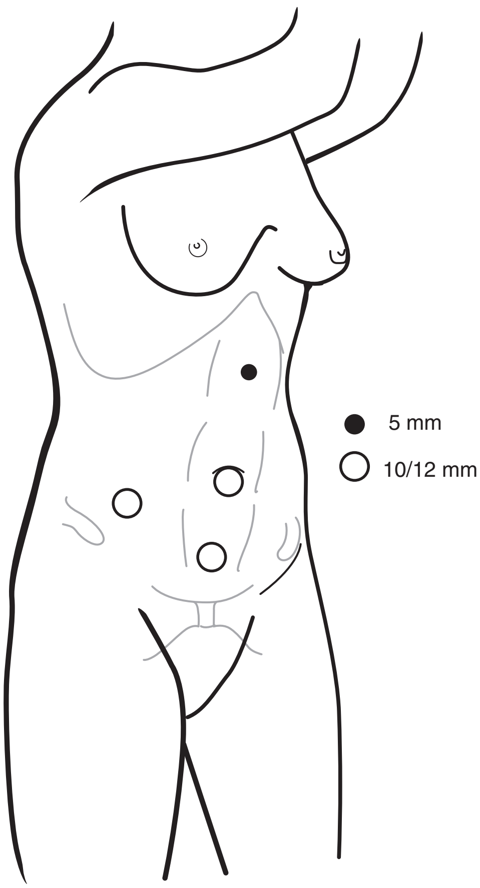


FIGURE 10–4. The trocars are placed in the midline for most patients. Markedly obese patients require a shift of the trocars laterally to allow for adequate visualization of the renal hilum and pelvic structures.

Alternatively, pass a suture on a straight needle through the abdominal wall and under the structure to be elevated or retracted, and pass the needle back out through the anterior abdominal wall. Then fix the suture in place with a hemostat (see Fig. 10–7). A low midline port can be helpful for dissection of the distal ureter.

PROCEDURE

Colon Mobilization

Following trocar placement, rotate the table to place the patient in a flank position. Incise the posterior peritoneum at the line of Toldt, allowing mobilization and displacement of the colon mesentery medial to the aorta on the right and vena cava on the left. For a right-sided dissection, carry the incision from the iliac vessels to the hepatic flexure. For a left-sided dissection, carry the incision cephalad to the splenic flexure (Fig. 10–6). Obtain retraction assistance using a straight needle passed from outside directly into the abdomen, around the ureter, and then back outside the abdomen (Fig. 10–7). Divide the renocolic ligaments to allow further mobilization of the colon off the lower pole of the kidney. Leave the lateral attachments of Gerota's fascia to prevent the kidney from falling medially during the dissection of the hilum (Fig. 10–8).

Nephrectomy

Identify the ureter medial to the lower pole of the kidney and dissect the ureter toward the renal hilum. Maintain a wide margin of tissue if an invasive ureteral tumor is known or suspected (Fig. 10–9). Carry the dissection cephalad to the renal hilum. Then carefully dissect and identify the major vessels. Ligate and divide the renal artery either with an endovascular gastrointestinal anastomosis device (GIA) or with multiple 10-mm clips and Endo Shears (Fig. 10–10). Apply a similar technique to any accessory arteries.

Next, turn attention to the renal vein. Identify lumbar, adrenal, and accessory veins and divide them between clips. Divide the renal vein with an endovascular GIA or locking clips (Fig. 10–11). Fully mobilize the kidney either inside or outside Gerota's fascia, depending on the tumor location and stage. Dissect with electrocautery or a harmonic scalpel to maintain hemostasis while freeing the upper pole of attachments (Fig. 10–12).

Distal Ureteral Dissection

Clip the ureter to prevent distal migration of tumor cells in the subsequent portion of the procedure. Continue the peritoneal incision in the inferior direction over the iliac vessels and medial to the median umbilical ligament to completely expose the ureter (Fig. 10–13). Carry out ureteral dissection as far distally

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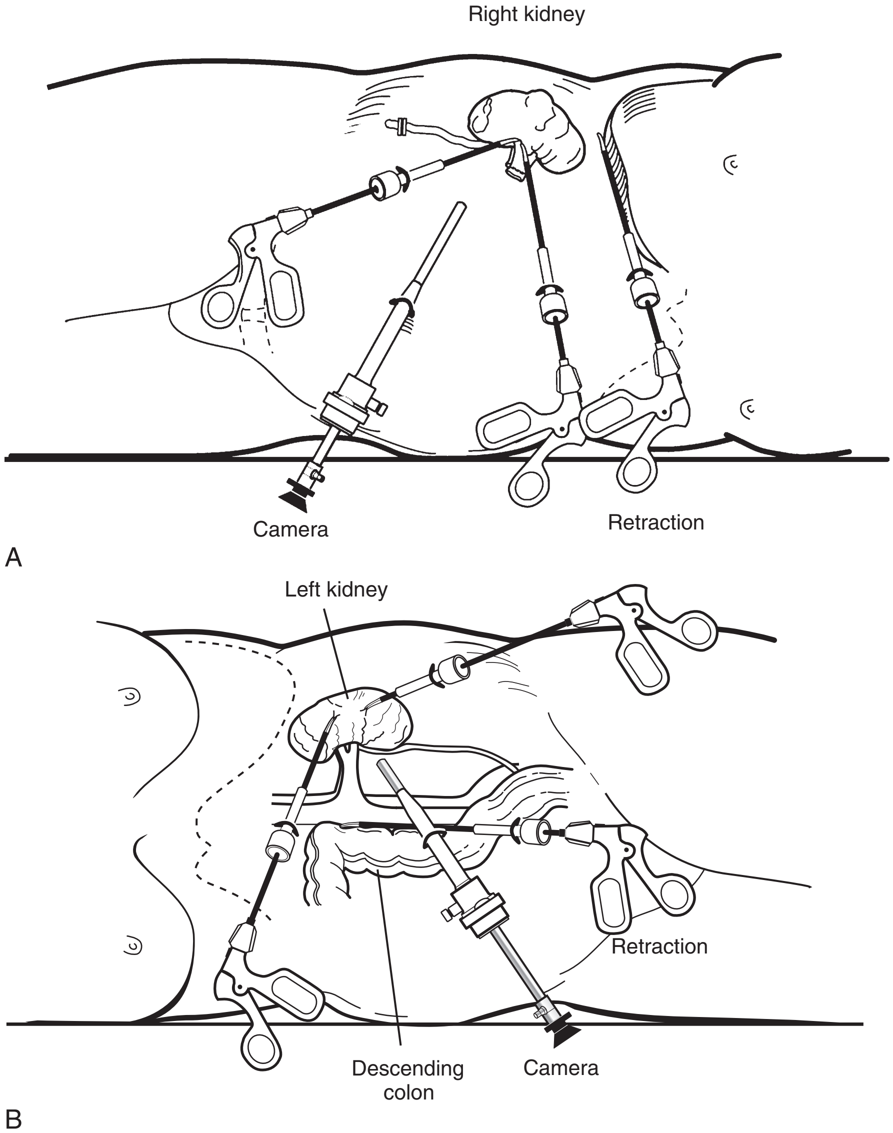

FIGURE 10–5. Accessory ports are placed as needed to retract surrounding organs. *A,* For right-sided lesions, a port below the xiphoid is helpful for retracting the liver. *B,* On the left side, a lower midline port is helpful for retracting the descending colon.

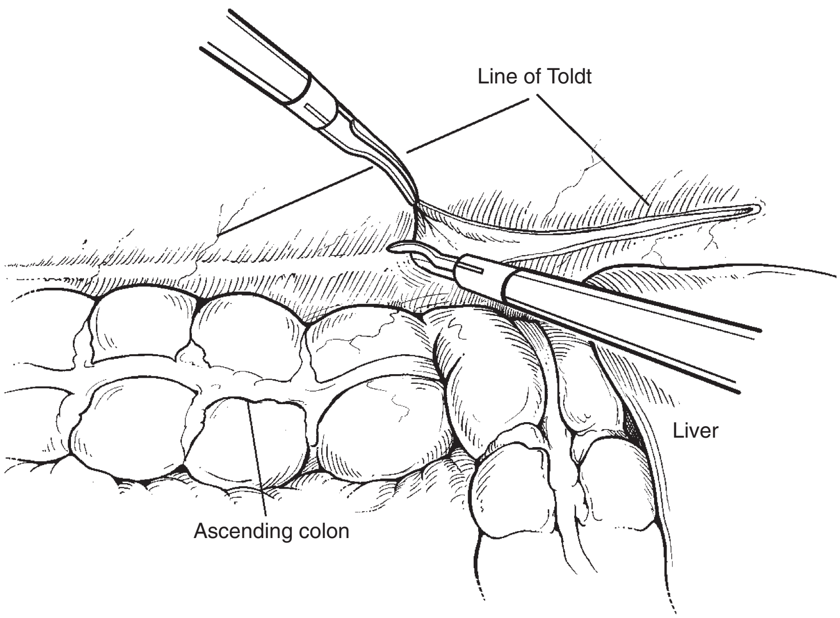

FIGURE 10–6. The lateral attachments of the colon are divided along the white line of Toldt followed by the renocolic attachments. The colon mesentery is mobilized medial to the aorta.

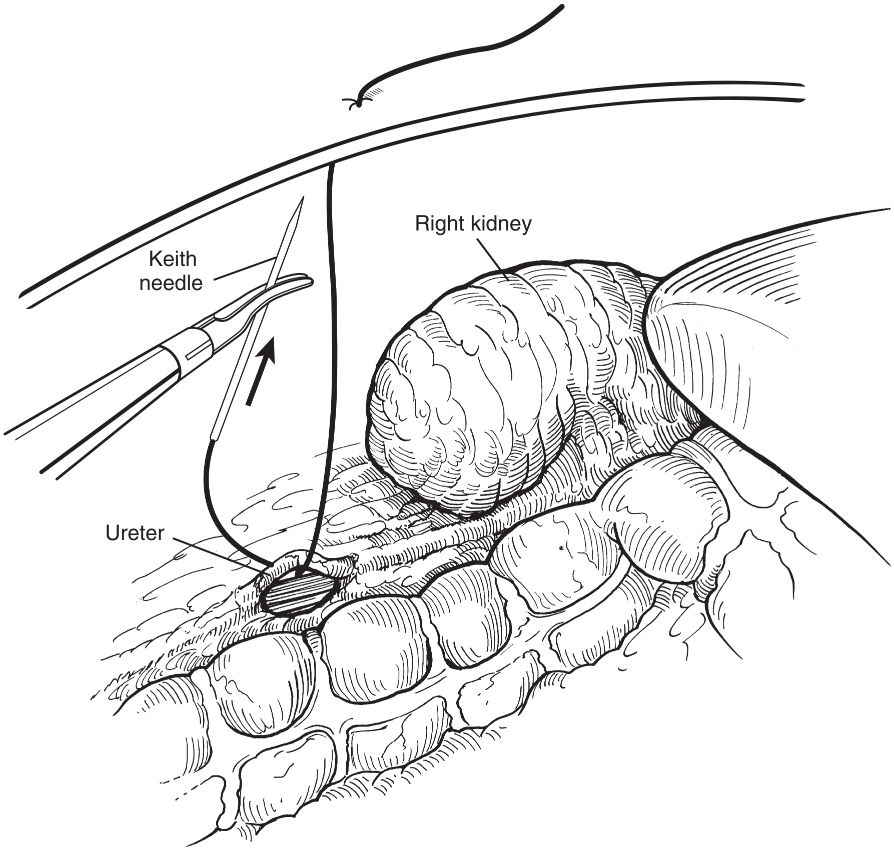

FIGURE 10–7. A suture on a straight needle can be used to elevate the ureter and assist with dissection.

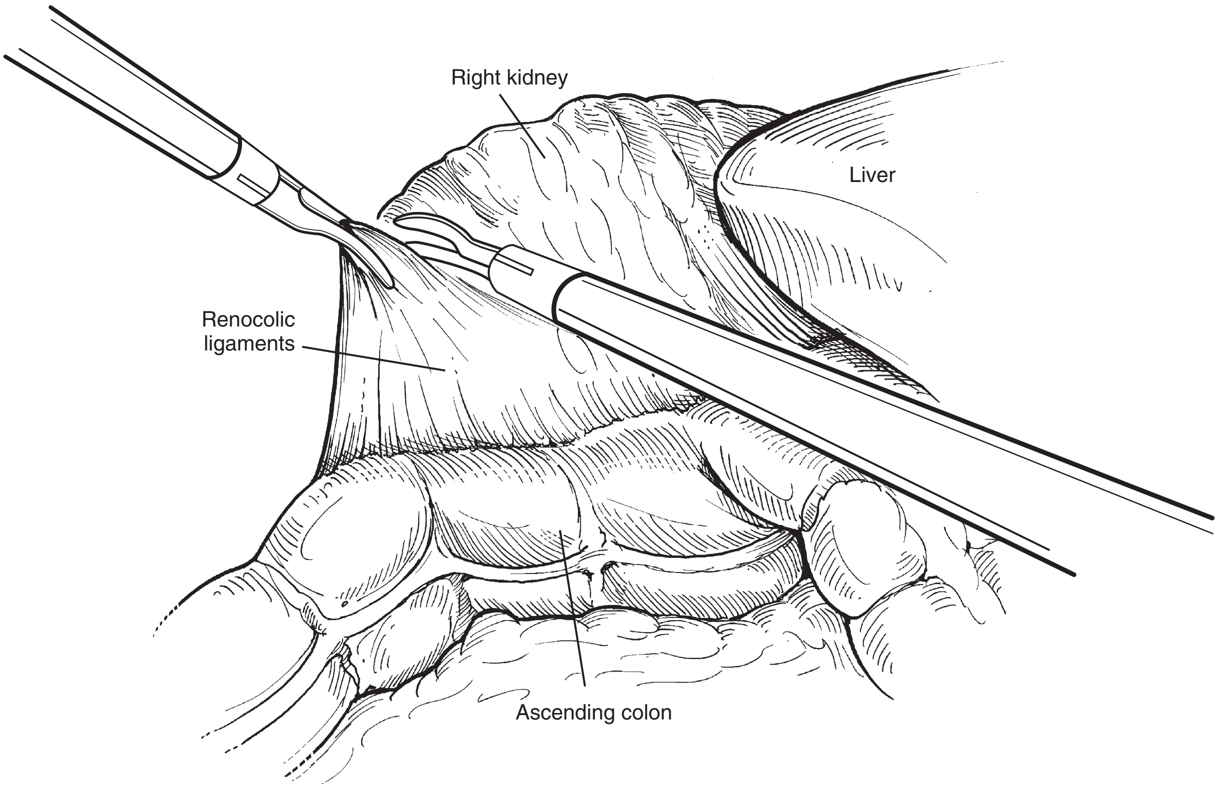

FIGURE 10–8. The renocolic attachments are freed from the kidney to expose the duodenum and renal vessels.

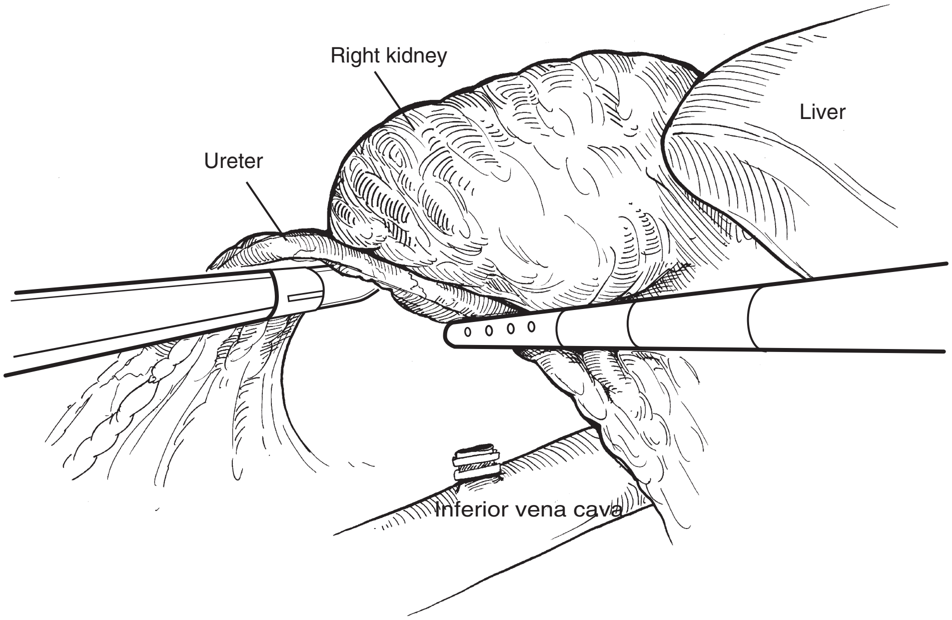

FIGURE 10–9. Once the bowel is reflected medially, a grasper is placed under the lower pole of the kidney placing the renal vessels on stretch. The renal hilum can then safely be dissected.

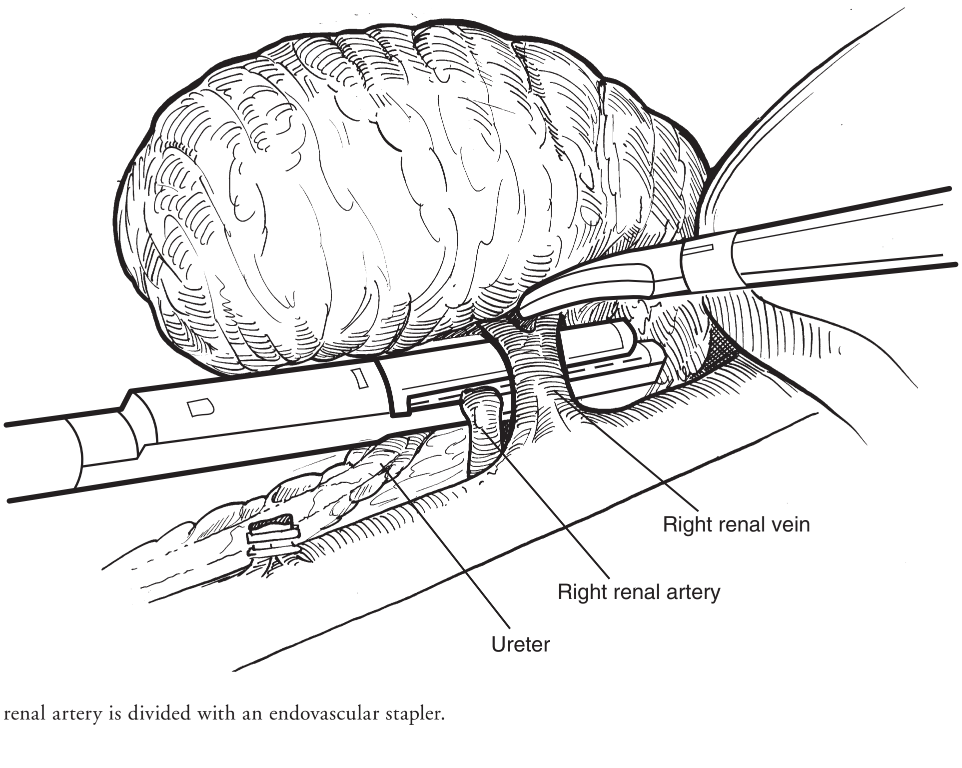

FIGURE 10–10. The renal artery is divided with an endovascular stapler.

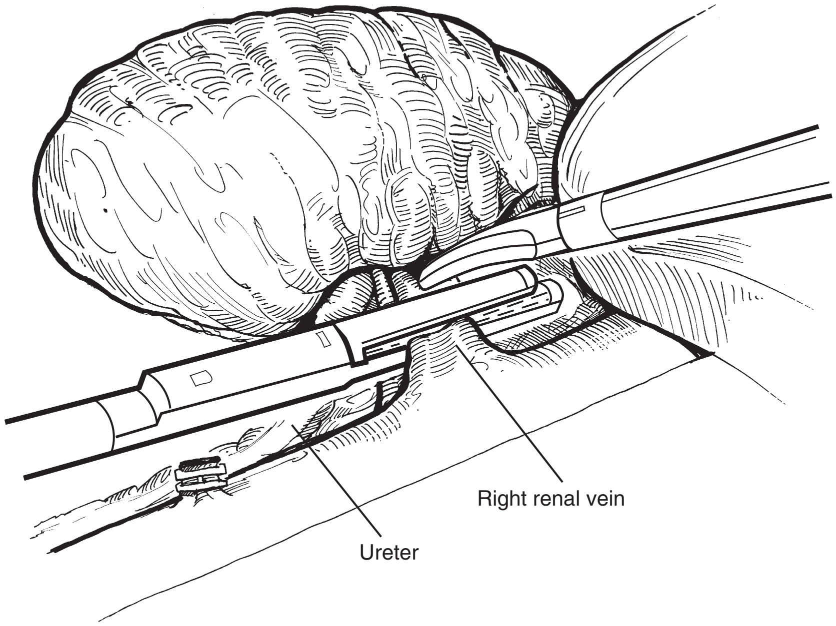

FIGURE 10–11. The renal vein is divided after the renal artery using the endoscopic vascular stapling device.

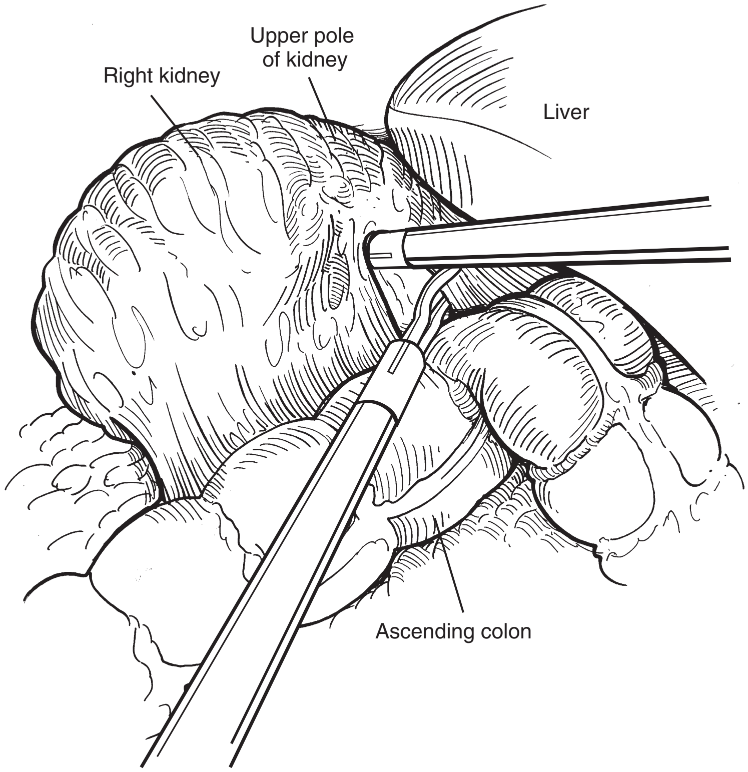

FIGURE 10–12. The upper pole attachments are divided, freeing the entire kidney.

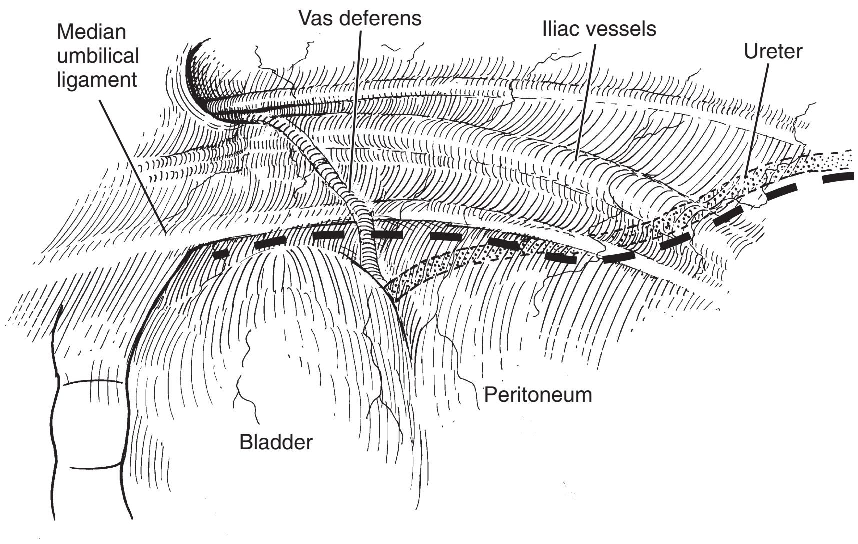

FIGURE 10–13. The peritoneal incision is extended deep into the pelvis over the iliac vessels and medial to the median umbilical ligament.

as possible, keeping wide margins of tissue at areas of known tumor. Generally, the ureter receives its blood supply anteromedially in the proximal third, medially in the middle third, and laterally in the distal third. Maintain hemostasis with electrocautery or clips, as needed. If needed, divide the vas deferens in the male or the round ligament in the female to allow easier subsequent dissection of the distal ureter.

If an open excision of the distal ureter is chosen, carry the dissection as far as can be comfortably done and strategically place the extraction excision to maximize exposure of the distal ureter. With ureteral dissection completed, again inspect the renal bed for bleeding and remove the trocars. Close port sites before starting the open portion of the procedure.

Management of the Distal Ureter and Bladder Cuff

Open Technique

The traditional method of open distal ureteral dissection and excision with a cuff of bladder remains the standard management technique.

Following completion of the nephrectomy portion of the procedure and after closing the port sites, carefully shift the patient to a supine position without violating the sterile field. Remove the shoulder bump, bring the ipsilateral arm back along the side of the patient, and rotate the ipsilateral hip to level.

The type of incision used largely depends on the patient's body habitus and the caudalmost level of ureteral dissection attained during the laparoscopic portion of the procedure (Fig. 10–14). If a low midline incision is chosen, make an anterior cystotomy and view the ipsilateral orifice. Then circumscribe the orifice and intravesically dissect the intramural ureter. With the bladder mobilized medially, dissect the ureter cephalad to the level of the initial dissection (Fig. 10–15). Deliver the specimen en bloc through the incision. Close the cystotomies with a standard two-layer closure.

The Gibson incision is preferable if the initial distal ureteral dissection was not carried distal to the iliac vessels or in a patient with extensive prior abdominal surgery. Expose the bladder and mobilize it to allow a posterolateral incision. Carry the incision around the ureter in a tennis racket shape. Extravesically dissect the entire intramural ureter and orifice and remove it (Fig. 10–16). Close the cystotomy with a standard two-layer closure. Leave a perivesical drain and a large-caliber Foley catheter for either approach, and close the incision in the standard fashion.

Pluck Technique

This method of managing the distal ureter was initially described as a minimally invasive approach to the bladder cuff for open nephroureterectomy[12,13] and subsequently applied as an adjunct to laparoscopic nephroureterectomy. It involves aggressive transurethral resection and disarticulation of the ipsilateral ureteral orifice before the nephrectomy portion of the procedure. This technique, however, does not control the distal ureter and allows spillage of the urine and potential tumor cells into the retroperitoneum. Local recurrence rates may be higher using this technique and have been reported.[14,15]

A more controlled variation of this technique is to perform the laparoscopic portion of the procedure first, with dissection of the ureter carried distally to the bladder. Tent up the ureter on slight tension, and use the endoscopic GIA device to ligate and divide the ureter. Remove the specimen through a low abdominal incision.

Following this, move the patient to the lithotomy position and carry out an aggressive transurethral resection of the ipsilateral ureter. This technique prevents urine spillage and more closely adheres to oncologic principles.

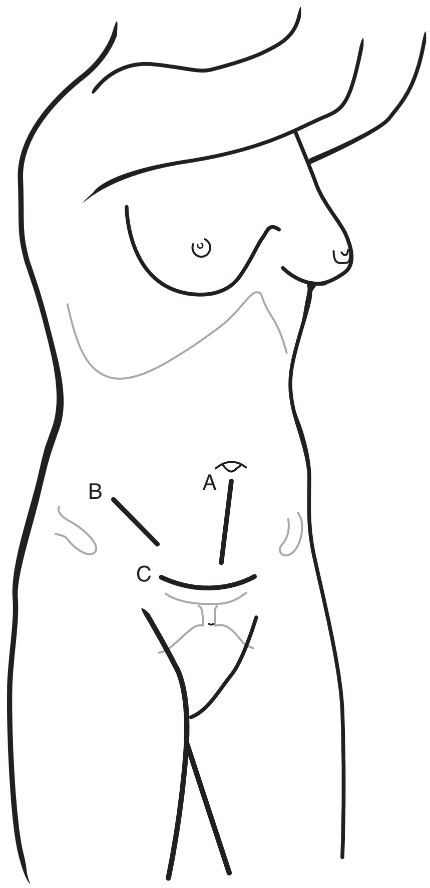

FIGURE 10–14. The type of incision for extraction largely depends on the distal extent of the ureteral dissection. A low midline or Pfannenstiel is adequate for dissecting the most distal ureter. A Gibson-type incision may provide better visualization of the mid ureter.

Laparoscopic Extravesicular Technique

With this technique, the entire ureteral dissection is performed laparoscopically. Dissect the ureter far into the pelvis until the detrusor is identified. Just as with an open approach, dissect the intramural ureter to the ureteral orifice. A cystoscope can be passed to ensure that the entire ureter has been dissected. Then place traction on the ureter and place a stapling device with a vascular load across the most distal ureter, including the ureteral orifice (Fig. 10–17). Then remove the specimen intact via a low abdominal incision. The bladder closure needs to be watertight, and the catheter can be removed 3 or 4 days postoperatively.

Ureteral Unroofing Technique

This technique is another endoscopic approach to the distal ureter performed immediately before laparoscopic nephroure-

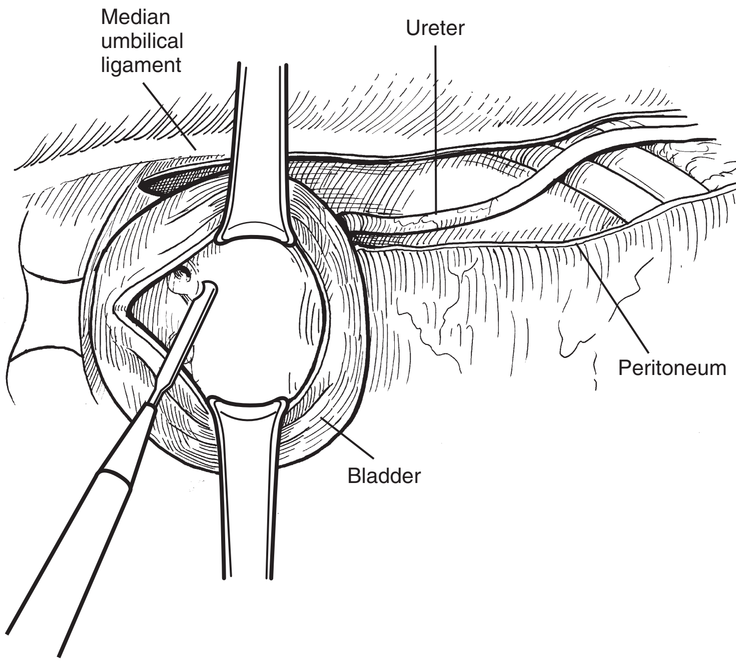

FIGURE 10–15. With a low abdominal incision, an anterior cystotomy can be used for transvesical dissection of the intramural ureter and bladder cuff.

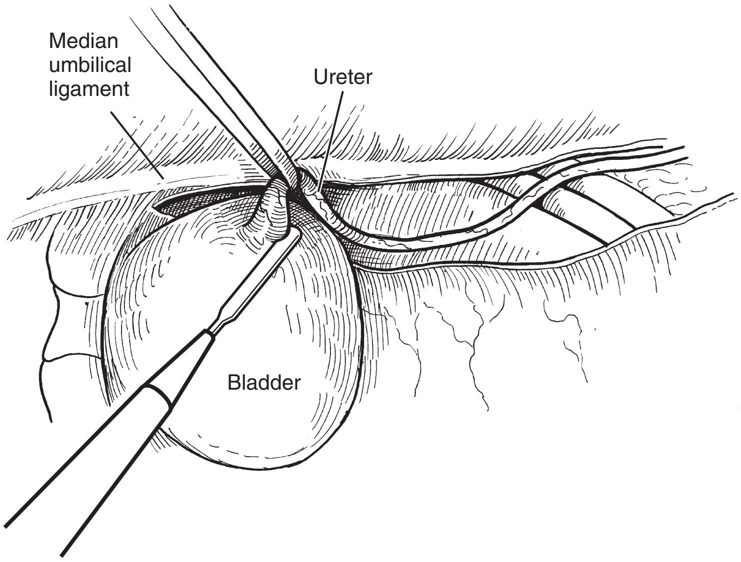

FIGURE 10–16. For an extravesicular open approach, the ureter is retracted superiorly and electrocautery used to circumscribe the ureter as it enters the muscle of the bladder.

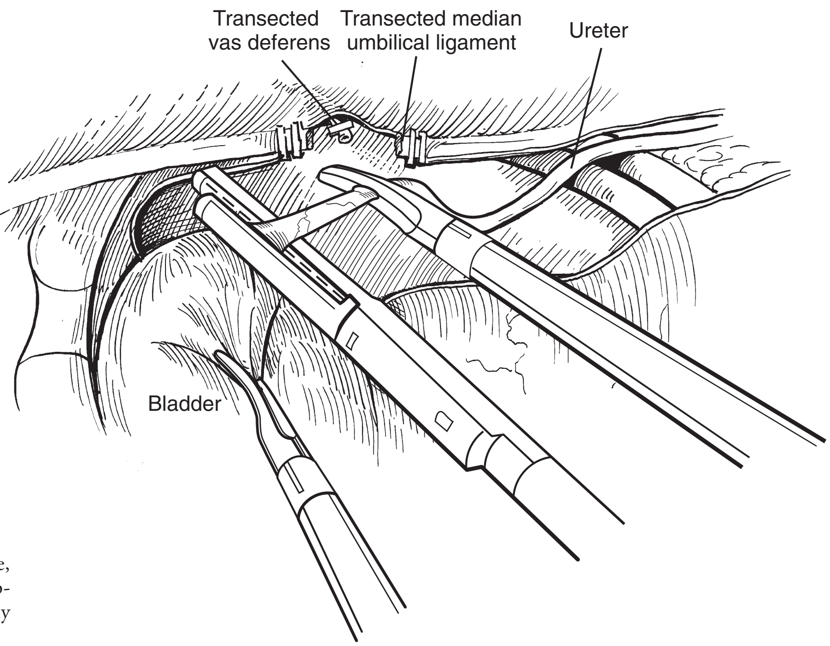

FIGURE 10–17. In the laparoscopic extravesicular technique, the ureter is dissected down to the bladder and retracted superiorly while the endovascular GIA stapler is placed as distally as possible to remove the entire ureter and a bladder cuff.

terectomy.[3,17,18] After induction, place the patient in dorsal lithotomy and place a 7-French, 10-cm–long ureteral dilating balloon over a wire into the distal aspect of the ipsilateral ureter under cystoscopic and fluoroscopic guidance and inflate it to less than 1 atm. Use a Collins knife to incise the ureteral tunnel anteriorly, at 12 o'clock going up to but not through the ureterovesical junction. Remove the balloon and cauterize the entire floor of the intramural ureter using a rollerball electrode. Finally, place a 7-French, 11.5-mm occlusion balloon catheter in the renal pelvis, under fluoroscopic guidance, and connect the balloon catheter to gravity drainage. Reposition the patient and carry out laparoscopic nephroureterectomy in the previously described fashion. Mobilize the ipsilateral ureter to the level of the bladder, which typically requires transection of the superior vesical artery. Ligate the distal ureter and bladder cuff and divide them with an endovascular GIA. Remove the specimen through an enlarged midline port site or a lower abdominal incision. This approach has the advantage of preventing urine spillage, but it is also time consuming and technically challenging. Of note, the titanium staples do not seem to create a nidus for stone formation within the bladder.[19,20]

Transvesical Laparoscopic Technique

This minimally invasive approach concentrates on the distal ureteral dissection initially and provides control of the distal ureter.[4,16] Following induction, place the patient in lithotomy, perform cystoscopy, and distend the bladder to capacity.

Transvesically insert two needlescopic or 3-mm ports. Balloon-tipped ports are recommended to prevent accidental removal and irrigant extravasation. Pass an EndoLoop through the port on the ipsilateral side of the ureter intended for removal and position the EndoLoop around the ureteral orifice. Advance a 6-French ureteral catheter to the mid ureter through the EndoLoop. Using a resectoscope with a Collins knife, circumferentially resect the ureteral orifice with approximately 2 cm of bladder cuff (Fig. 10–18).

Pass a small grasping device through the free port and use this device to tent up the ureter while resecting it, allowing en bloc detachment of the bladder cuff. When entirely mobilized, tightly cinch the EndoLoop around the ureter. Either remove the ureteral retrocatheter while tightening the loop or leave it in place as an aid during laparoscopic dissection. At this point, remove the transvesical ports and resectoscope and place a Foley catheter. Reposition the patient, and carry out laparoscopic nephroureterectomy as previously described. Confirm the distal ureteral margin by the presence of the EndoLoop. Remove the intact specimen via an enlarged midline port site or thorough a separate low abdominal incision.

This approach has shown oncologic effectiveness at intermediate-term follow-up[7]; however, it is technically challenging and time consuming, requires repositioning of the patient, and carries the potential risk of irrigation extravasation through the transvesical ports. This approach is not feasible in patients with concurrent bladder tumors or in those who are morbidly obese.

POSTOPERATIVE MANAGEMENT

A perivesical closed suction drain is left in place for 1 to 3 days postoperatively until there is minimal drainage. Regardless of the technique implemented to manage the distal ureter and

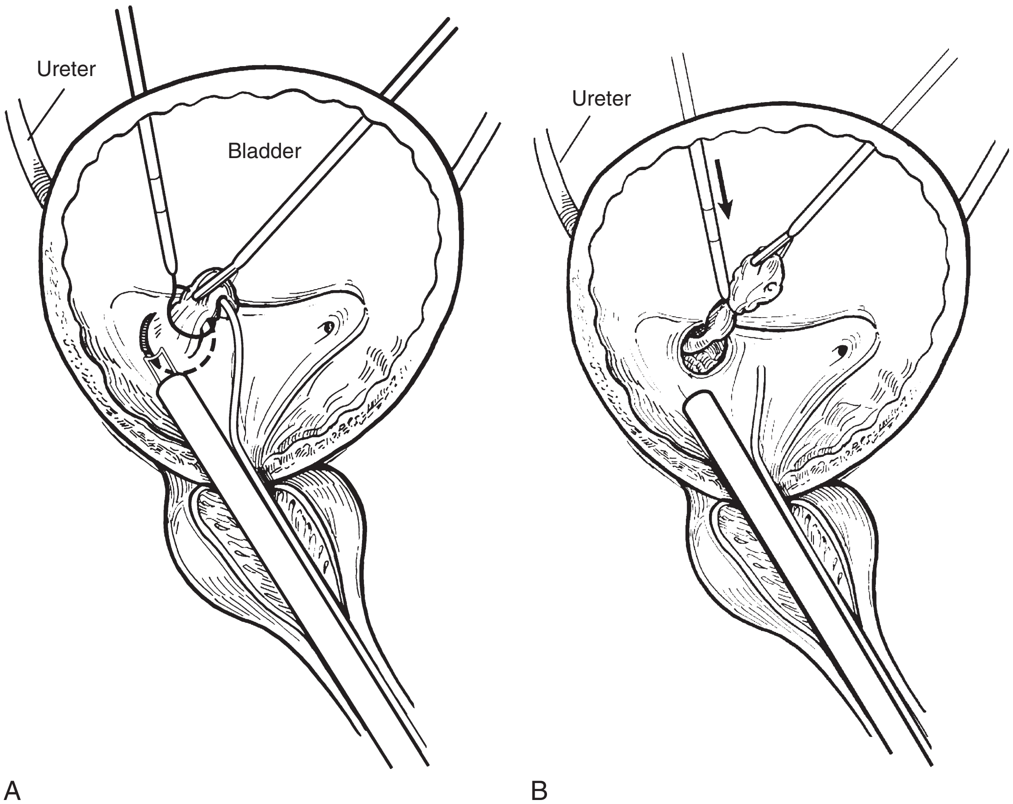

FIGURE 10–18. *A,* This less-invasive technique involves two ports in the bladder for retraction of the ureter and a resectoscope with a Collins knife in the bladder. *B,* The ureter is dissected proximally until perivesical fat is visualized, and an EndoLoop is used to secure the distal end of the ureter.

bladder, the Foley catheter remains in place for 7 to 10 days after surgery. A cystogram is routinely obtained before removal to ensure complete closure of the cystotomy. The orogastric or nasogastric tube is removed at the end of the case unless there is concern for prolonged recovery of bowel function. Oral fluids are given when there are signs of bowel activity, and the diet level is advanced after the passage of flatus.

COMPLICATIONS

Potential complications related to laparoscopic nephroureterectomy and their management are similar to those associated with other abdominal laparoscopic procedures and are well described.[21] Intraoperative complications include blood loss requiring transfusion and injury to liver, spleen, pancreas, bowel, or vascular structures. All involved must be prepared for immediate conversion to an open procedure. Give careful attention to the contralateral ureteral orifice during dissection to prevent inadvertent injury. Postoperative complications include neuromuscular pain secondary to positioning, hematoma formation, wound infection, prolonged ileus or small bowel obstruction, adhesion formation, and prolonged urine leakage.

SUMMARY

Laparoscopic nephroureterectomy is a safe operation when performed carefully, and it can parallel the oncologic control obtained by open surgery with decreased morbidity and duration of convalescence. Controversy still exists regarding the ideal management of the distal ureter and bladder cuff. The optimization of oncologic control and minimally invasive surgery must be carefully balanced between complex and time-consuming procedures. In the future, more reliable and consistent methods of managing the distal ureter without the need for a lower abdominal incision may develop.

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CHAPTER 11

Laparoscopic Donor Nephrectomy

Adam J. Ball
Michael D. Fabrizio
Edwin L. Robey

In 1954, the first renal transplantation was successfully performed. Because the patients were identical twins, the first living-related and live donor transplantations were also documented. Now, more than 50 years later, renal transplantation remains the only potential treatment option other than dialysis for patients with end-stage renal disease. A wide disparity exists between the number of patients registered in need of a renal transplant and the number of donated kidneys available. A traditional flank incision has been used for donor nephrectomy, but the morbidity associated with the procedure stimulated investigation for alternative approaches. In 1995, Ratner and associates[1] successfully performed the first laparoscopic live donor nephrectomy in an attempt to decrease the perioperative morbidity. In the ensuing decade, laparoscopic live donor nephrectomy became widely accepted around the world and has superseded open live donor nephrectomy at many transplant centers as the procedure of choice for kidney retrieval.[2,3] Laparoscopic donor nephrectomy (LDN) has been shown to reduce the disincentives to living renal donation, thus potentially increasing the supply pool of willing donors.[4]

Surgical outcomes are critical to the evaluation and future success or failure of a novel procedure, and this is certainly the case with regard to live LDN. Just as important as a successful surgery for the donor, the donated kidney must function and survive within the recipient. Troppmann and colleagues[5] analyzed the U.S. United Network for Organ Sharing (UNOS) database and compared the outcomes of 2734 kidney transplants following LDN with the outcomes of 2576 kidney transplants following open donor nephrectomy (ODN) from November 1999 through December 2000. Although LDN recipients experienced slower early post-transplant graft function, there was no significant difference in graft survival at 1 year (94.4% for LDN versus 94.1% for ODN). In addition, there was no observed difference in the incidence of acute rejection between groups (<20% at 1 year in both groups).

INDICATIONS AND CONTRAINDICATIONS

LDN is performed to surgically retrieve a normally functioning kidney in order to donate it to a patient with end-stage renal disease. Preemptive donation and subsequent transplantation may also occur before the onset of end-stage renal disease.

Extensive upper intra-abdominal surgery is the only relative contraindication to LDN.[2]

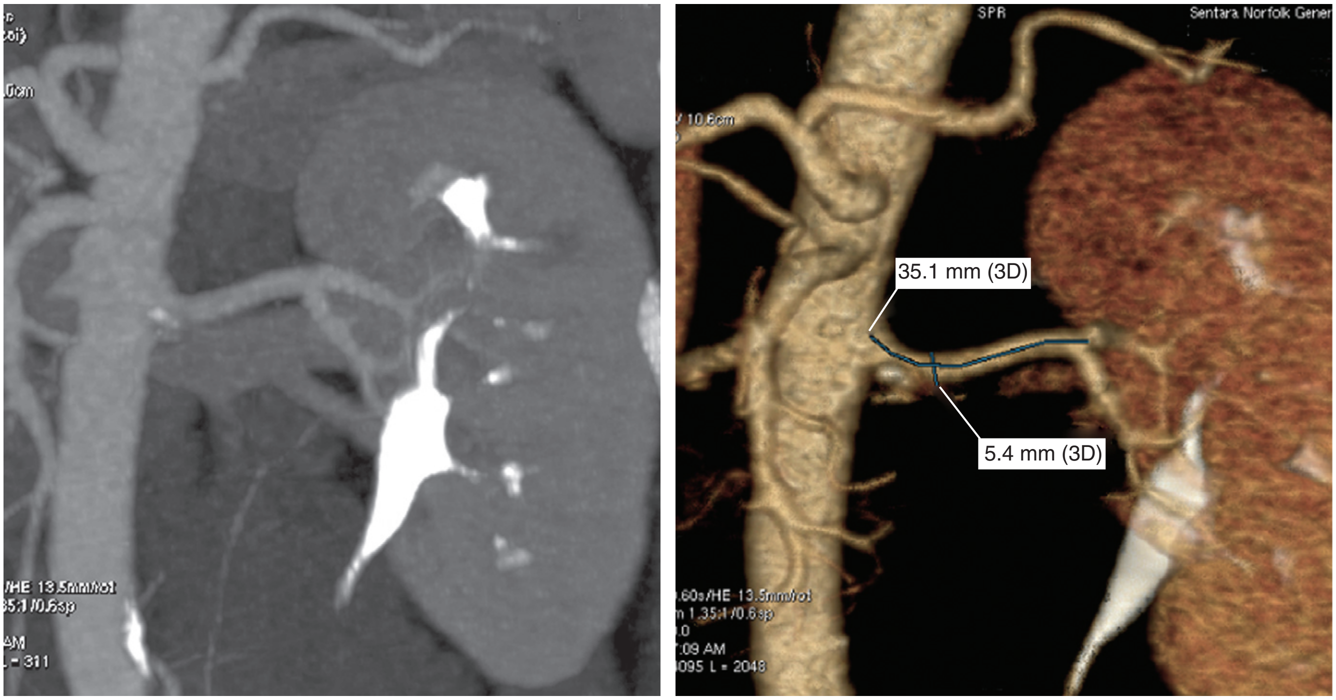
PATIENT PREOPERATIVE EVALUATION AND PREPARATION

Preoperative evaluation involves extensive medical and psychological evaluation in accordance with the published guidelines of the America Society of Transplantation. This type of evaluation is coordinated by the transplant team and usually includes a thorough history and determination of the patient's motivation and emotional stability, a physical examination, laboratory studies, computed tomography (CT) scanning, and histocompatability testing. Once the patient is determined to be a candidate and surgical donation has been planned, he or she is clinically evaluated by the urologic surgeon at our institution who will be responsible for the laparoscopic procedure. Renal and ureteral anatomy and vascular supply are further reviewed to determine whether the left or right kidney will be removed. CT angiography with three-dimensional reconstruction has an accuracy of greater than 90% for predicting the arterial anatomy,[6] and it has become routine at our institution during the preoperative assessment of the potential living donor (Fig. 11–1). We prefer to perform a left-sided LDN whenever possible, even when presented with multiple renal arteries.[7] Others, however, prefer to perform a right-sided LDN in an effort to maintain organ selection criteria similar to open donation.[8] Finally, any potential urologic problems, such as nephrolithiasis, hematuria, or urinary tract infections, are addressed preoperatively.

OPERATIVE ROOM CONFIGURATION AND PATIENT POSITIONING

A dedicated laparoscopic operative suite has been developed at our institution. A consistent nursing and surgical assistant staff is routinely assigned to this room. A successful procedure starts with proper operative suite configuration and team preparation.

Position a standard operative table in the center of the room. Maintain anesthesia at the head of the table. The surgeon and assistant surgeon operate on the same side of the table facing the opposing monitor. The scrub nurse is positioned near the patient's feet, where a Mayo stand and instrument table are within immediate reach. Digital monitors and laparoscopic instrumentation are supported by large booms that are anchored to the ceiling (Fig. 11–2). This obviates the requirement of large and often bulky laparoscopic video towers. Gas for insufflation travels to the room via a central supply area in the hospital's



A B

FIGURE 11–1. *A,* Computed tomography angiography showing detailed vascular anatomy. *B,* Corresponding three-dimensional (3D) reconstruction.

basement and therefore provides a continuous supply during the procedure without the need for untimely tank transition. Online radiography is accessible from the operative suite. Advanced technology is available for digital recording, remote surgical telecasting, and robotic assistance. Although the aforementioned suite is optimal, laparoscopic video carts can suffice.

Donor patients do not undergo any specific bowel preparation. Administer a routine preoperative intravenous antibiotic in the absence of any known allergic reactions. Bring the patient into the room awake and move the patient to the operative table. Place sequential compression devices on both lower extremities. The anesthesiologist administers general endotracheal anesthesia. After establishing adequate peripheral venous or arterial access, place an orogastric tube and insert a Foley catheter with sterile technique.

Begin preparation of adequate patient positioning. This is performed in three steps, which are coordinated with the anesthesiologist, who secures the patient's head and endotracheal tube, and the surgical team:

1. Move the patient down the table until the flank is over the break in the table.
2. Shift the patient away from the edge of the table where the surgeon(s) will be standing.
3. Rotate the patient into a modified decubitus position (Fig. 11–3).

Use appropriate upper and lower body padding, including an axillary roll. Bend the downside leg at the knee and leave the upside leg relatively straight. Place padding underneath the downside knee and ankle, and place two or three pillows between the two legs. Place two rolled sheets along the patient's back for stabilization. Do not use a beanbag device or a gelfoam pad. Position the upside arm across the body and place it in a padded arm hanger (Allen; Edgewater Medical Systems, Mayfield Heights, OH) (Fig. 11–4). Flex the bed approximately 50% and then secure this arm. The arm must not interfere with planned surgical instrument maneuvers. Also pad the downside arm with foam and bend it slightly at the elbow to mimic a natural position. Place Velcro body straps at several points across the body. Use silk tape to further secure the patient to the table. Take care to limit tape contact with the skin and to avoid overtightening. Tilt-test the bed in both directions for a final check of patient security. Following cleansing with alcohol, make a small scratch mark in the midline 2 cm above the pubic symphysis. Prep and drape the patient in the usual sterile fashion.

TROCAR PLACEMENT

Left Side

Trocar placement for a left-sided approach is described. Establish pneumoperitoneum using the Veress needle. Place the needle lateral to the umbilicus and lateral to the rectus muscle, thus decreasing the risk of injury to the epigastric vessels. Often, three "pops" of the Veress needle are felt.

Next, perform a water-drop test using a 10-mL syringe filled with sterile saline. First aspirate the needle to ensure that it is not in any viscus or vascular structures. Then inject a few drops of saline and allow them to fall freely into the peritoneal cavity. Full withdrawal of the needle and repositioning may be necessary if the drops do not fall freely. Insufflate with CO_2 under low pressure and low flow; optimal pressure is 6 mm Hg or less.

Once a full pneumoperitoneum is established (15 mm Hg), determine port placement. Place a 10/12-mm port in the left

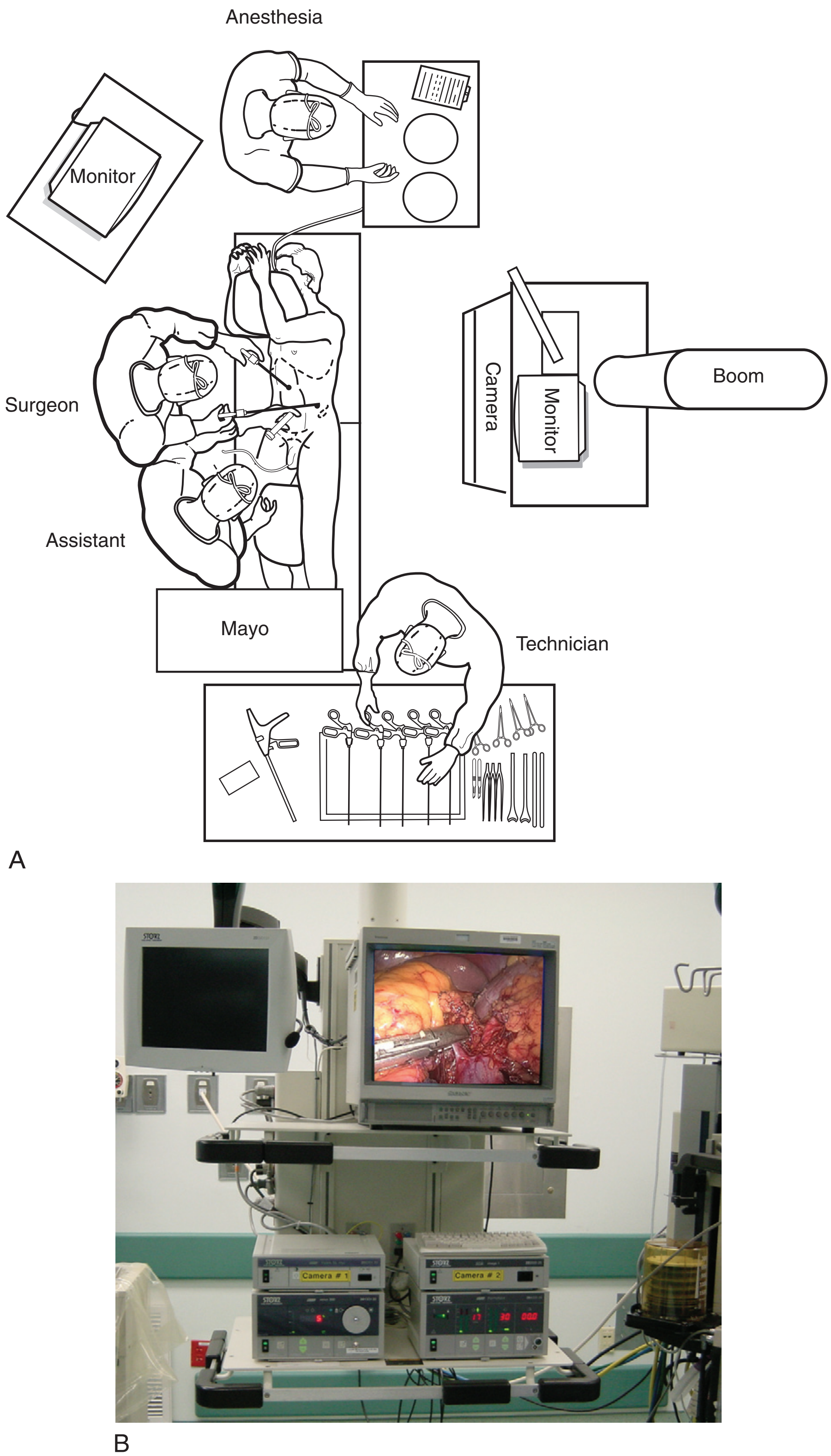


FIGURE 11–2. *A,* Configuration of the operating room including the position of personnel and equipment. *B,* Laparoscopic tower on movable arm.

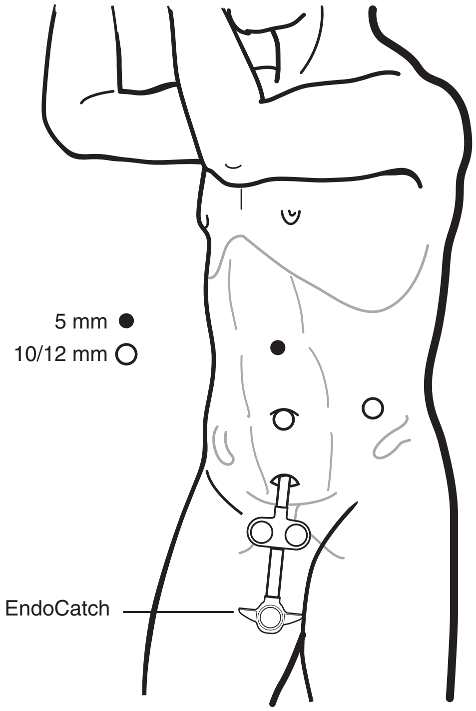


FIGURE 11–3. Left-sided trocar placement: open circles show 10/12-mm port lateral to the rectus muscle at the level of the umbilicus and 10/12-mm port at the umbilicus, and filled circle shows 5-mm port in the midline between the umbilicus and the xiphoid process. A fourth port (10/12 mm) can be placed approximately two fingerbreadths above the symphysis to accompany the EndoCatch (U.S. Surgical) device, which can be used for retraction and retrieval. Modified left-lateral decubitus position for left-sided LDN. The 15-mm EndoCatch device can be used as a retractor through the Pfannenstiel incision. The shaft of a padded retractor is used as a retractor during the procedure. The EndoCatch or hand can be used for organ retrieval.

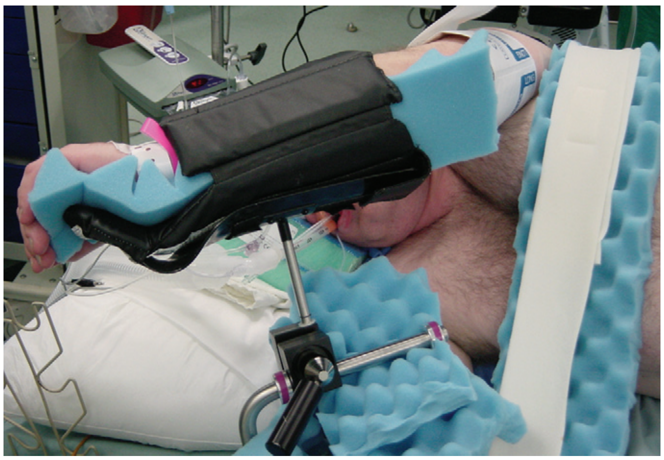


FIGURE 11–4. Allen support system for "upside" hand, wrist, and arm.

midclavicular line using a 10/12-mm Optiview nonbladed trocar (Ethicon Endo-Surgery, Cincinnati, OH). Apply gentle pressure and a twisting motion to insert the trocar under direct vision. Once placed, remove the obturator and attach insufflation tubing to this port. Use the 30-degree lens, and perform a brief inspection of the abdomen. Identify location of bowel attachments and adhesions. Keep a metal canister of hot saline on the back table and use it to warm the lens before each time it is inserted into the trocar. Do not use defogging solution. Place the remaining trocars under direct vision. Place a second 10/12-mm trocar, using the blunt tip, at the umbilicus, and place a third 10/12-mm trocar subxiphoid in the midline. The size of the ports allows rapid transition of different-sized instruments described later. Use the Carter-Thomason port-closure device (Inlet Medical, Inc., Eden Prairie, MN) to place a 0 Vicryl (polyglactin) suture around each trocar site intended for closure at the conclusion of the procedure. Switch the insufflation tubing to the umbilical trocar, which will become the camera location. Begin dissection.

When additional retraction is required by the assistant surgeon, insert a fourth 10/12-mm trocar, if needed. Make a 7- to 8-cm low transverse incision 2 cm above the pubic symphysis. Carry dissection down until the rectus fascia is identified. Then, under direct laparoscopic vision, insert the trocar in the midline. Usually, use a laparoscopic paddle retractor through this trocar site.

Right Side

Trocar placement for a right-sided approach is a mirror image of left-sided placement. Laterally place an additional 5-mm trocar below the costal margin. Place a laparoscopic flexible retractor, if needed, via this port for hepatic retraction. Then secure the laparoscopic retractor to the "iron intern" self-retracting system.

PROCEDURE

Left Sided

During LDN, it is imperative to maintain adequate intravenous crystalloid hydration (4–6 L) and patient diuresis. Crystalloid hydration maintains renal perfusion and a healthy renal allograft. Administer mannitol in two 12.5-g doses early in the procedure, and use furosemide (Lasix) to maintain a brisk urine output.

Because the left kidney is usually procured, we present here description for a left LDN. Using a laparoscopic Debakey forceps and endoshears, incise the ipsilateral lateral colonic attachments and the phrenocolic ligaments to fully mobilize the colon medially (Fig. 11–5). Use extreme caution to prevent thermal injury to the colon. Divide the lienorenal and splenocolic ligaments, which allows adequate splenic retraction. Incise the colorenal ligaments and Gerota's fascia using the 10-mm LigaSure (Valleylab, Boulder, CO), and identify the anterior renal capsule (Fig. 11–6). Inferiorly, expose the psoas muscle and identify the gonadal vein and ureter along the medial border of the muscle (Fig. 11–7). Carry dissection distally to the level of the iliac vessels. Dissect the gonadal vein and ureter en bloc because preservation of periureteral tissue is important to provide a healthy ureter for implantation (Fig. 11–8). Routinely, insert a fourth 10/12-mm trocar 2 to 3 cm above the pubic symphysis in the extraction site. Typically, retract with a paddle retractor.

Trace the gonadal vein to its insertion into the main renal vein. Occasionally, variants are encountered. Next, focus attention on the upper pole and the adrenal gland. Usually, cautious blunt dissection reveals a plane along the posterior aspect of the

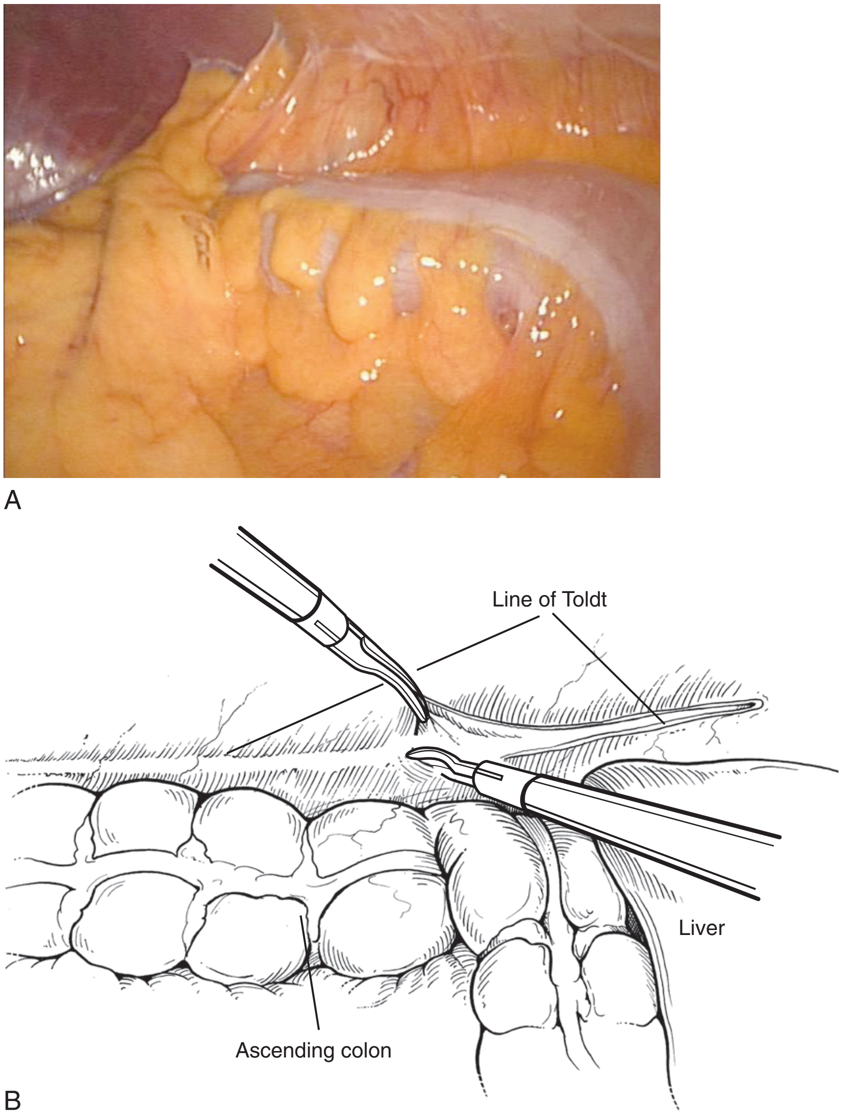


FIGURE 11–5. An incision is made along the lateral peritoneal reflection (line of Toldt), and the colon is reflected medially using blunt and sharp dissection. Lateral colonic attachments are identified (*A*) and dissected sharply (*B*).

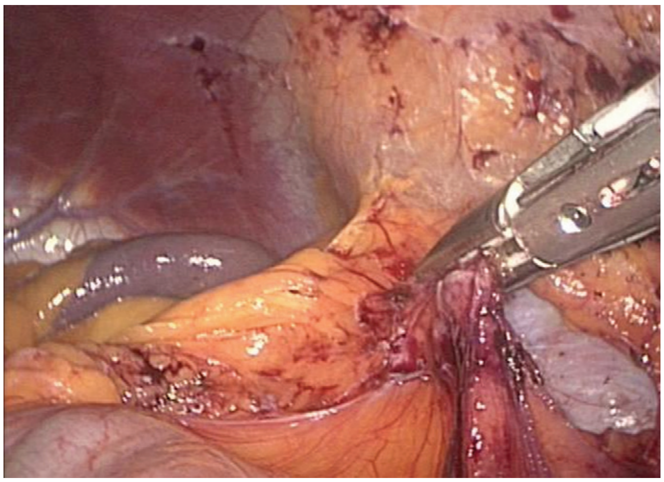


FIGURE 11–6. Exposure of renal capsule through Gerota's fascia using the LigaSure device.

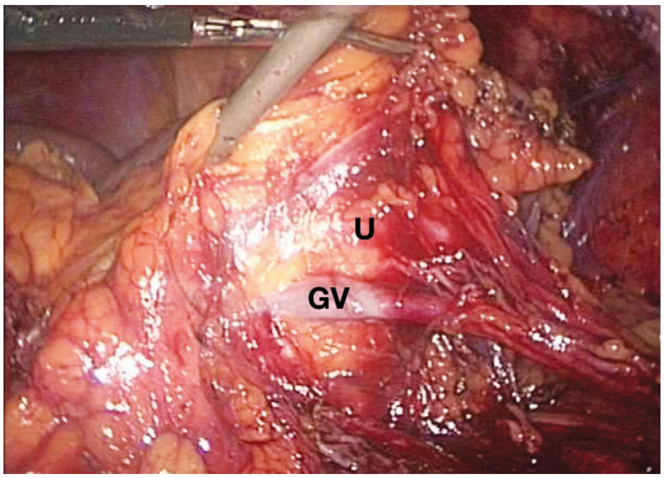


FIGURE 11–7. Identification of gonadal vessels (GV) and ureter (U) along the medial border of the psoas muscle.

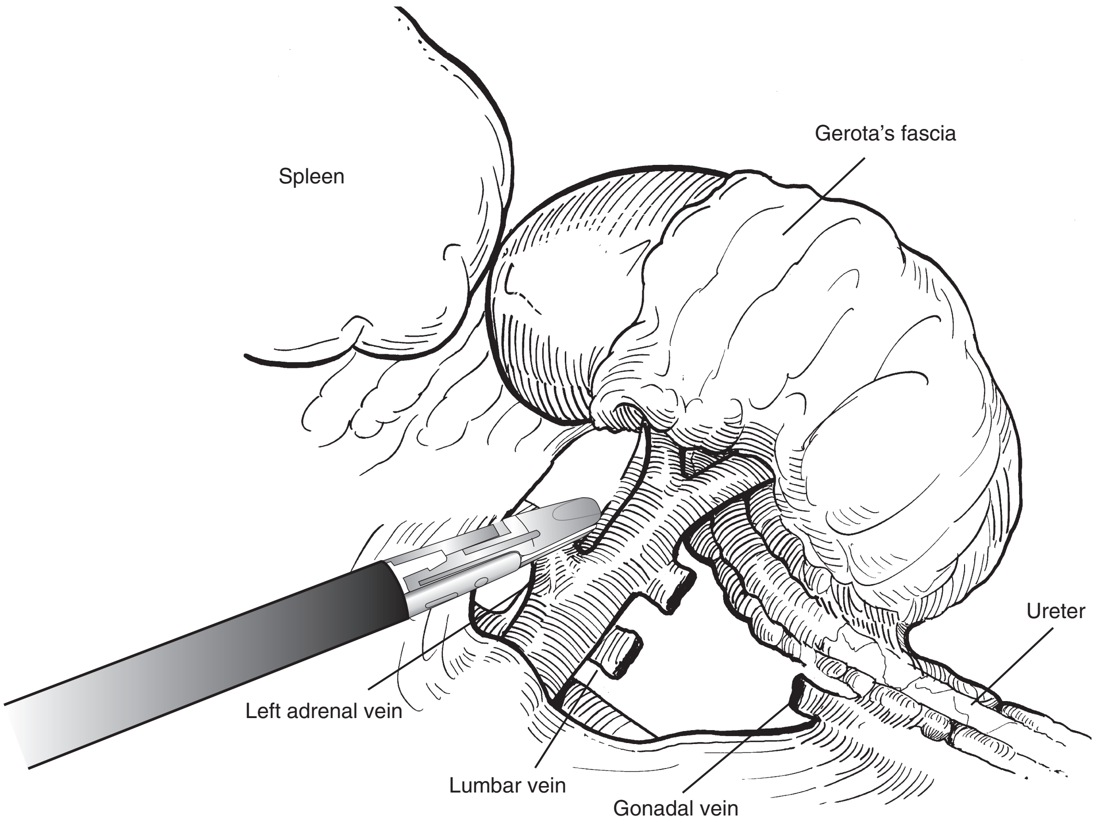


FIGURE 11–8. The gonadal and lumbar veins have been divided with the LigaSure atlas. The gonadal vein is left attached to and dissected laterally with the ureter to preserve the periureteral blood supply. The adrenal is also divided with the LigaSure Atlas.

upper pole. Once freed, retract the upper pole anteriorly and dissect the adrenal gland. Medial incision of Gerota's fascia results in complete hilar exposure. Dissect the vein free beyond the adrenal vein insertion, thus providing as much length as possible for transplantation. A posterior lumbar vein is usually encountered. Secure and transect the gonadal, adrenal, and lumber veins using the LigaSure device.[9] This avoids troublesome clip placement, and we have not encountered any major hemorrhagic complications using this device (Fig. 11–8).

Solitary or multiple renal arteries may be present, as identified on preoperative imaging. The arterial supply is usually located posterior to the venous drainage; however, various anomalies may be encountered. Use gentle dissection to avoid arterial vasospasm and subsequent renal ischemia. The monopolar hook electrocautery facilitates the dissection through the abundant hilar lymphatic network. The renal artery is completely exposed proximally to its origin. Administer papaverine via a laparoscopic cyst aspiration needle when vasospasm does occur. The kidney is finally released from its lateral attachments, and careful medial retraction of the kidney exposes the hilar vessels from a posterior approach (Fig. 11–9). Dissect the remaining lymphatic vessels. At this point, the kidney is tethered only by the hilar vessels and the ureter (Fig. 11–10). Clip the distal ureter using a right-angle clip applier only after the recipient team has instructed the donor team to do so (Fig. 11–11). Use EndoShears for sharp division, and allow the proximal ureter to freely drain during the final moments of the procedure.

Immediately before hilar transection, scrub and prepare the sterile back table. Make a low transverse skin incision extending

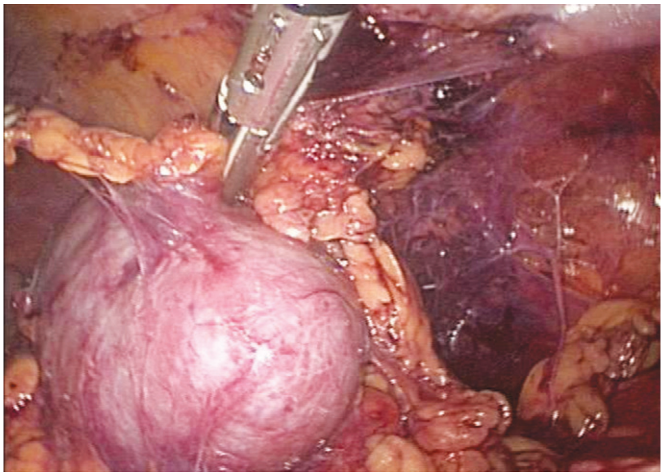


FIGURE 11–9. Lateral attachments are divided.

outward a few centimeters from the previously placed fourth trocar site. Make the incision to accommodate one hand, avoiding loss of pneumoperitoneum. Transversely incise the anterior fascia and split the rectus muscle in the midline. Extend the peritoneum and remove the trocar. Wrap the wrist with a single, moist laparotomy pad, place a sterile sleeve over the pad up past the elbow, and place a second glove over both the pad and sleeve. This technique provides for manual specimen extraction and avoids unnecessary retrieval bag manipulation and the

requirement for a pneumoperitoneum-preserving device.[10] Move the camera to the lateral trocar site, and maintain hilar exposure with the intraperitoneal hand. We administer 3000 units of intravenous heparin sulfate 2 minutes before extraction.

Using a Multifire Endo GIA 30 stapling device with 2.0-sized staple loads (U.S. Surgical, Norwalk, CT), divide the arterial supply first (flush with the aorta [Fig. 11–12]) and divide the renal vein subsequently (proximal to the adrenal vein stump [see Fig. 11–12*B*]). Extract the kidney, immediately place it in ice slush, and transfer it to the awaiting transplant surgeon. Administer protamine sulfate (30 mg) to reverse the anticoagulation. Inspect the peritoneal cavity under low pressure to check for hemostasis, and give particular attention to the staple lines. Remove the trocars under direct vision, and close the sites. Close the lower incision in standard fashion. Do not place any drains. Close all skin incisions using a subcuticular technique, and apply dressings.

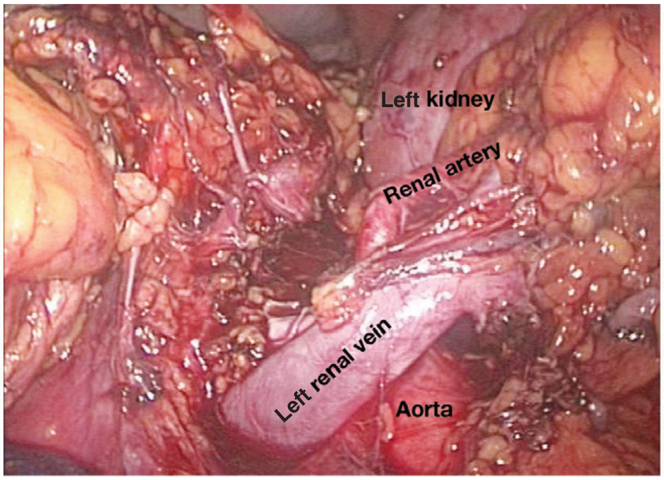


FIGURE 11–10. Completed dissection showing the left main renal vein, renal artery, aorta, and left kidney.

Right Sided

A similar technique is performed for a right-sided LDN with only a few modifications. Insert a flexible retractor through the additional, lateral 5-mm trocar and position it beneath the liver to provide adequate exposure. Dissection involves medially reflecting the duodenum (Kocher maneuver) to further expose the short right renal vein. To provide sufficient venous length, use an endovascular TA stapling device for hemostasis. The TA device places only three rows of staples (rather than six rows provided by the GIA device) and does not transect. Use Endo-Shears to sharply transect the renal vein.

POSTOPERATIVE MANAGEMENT

The orogastric tube is removed immediately following procedure completion. Patients are admitted to a surgical care ward for postoperative management. Ambulation is encouraged once the patient has recovered from anesthesia. Intravenous hydration is maintained to ensure adequate urinary output. A diuresis is often observed following the procedure. Renal function and blood count are monitored. Patient analgesia is usually provided via oral routes, and patient-controlled analgesia is added only if pain scores are elevated. Diet is advanced appropriately as bowel function returns. Occasionally, postoperative ileus occurs. Foley catheter removal and subsequent voiding trial generally occur on the second postoperative morning. Except for anonymous donors, the donor is encouraged to visit with the recipient should each patient's clinical course permit.

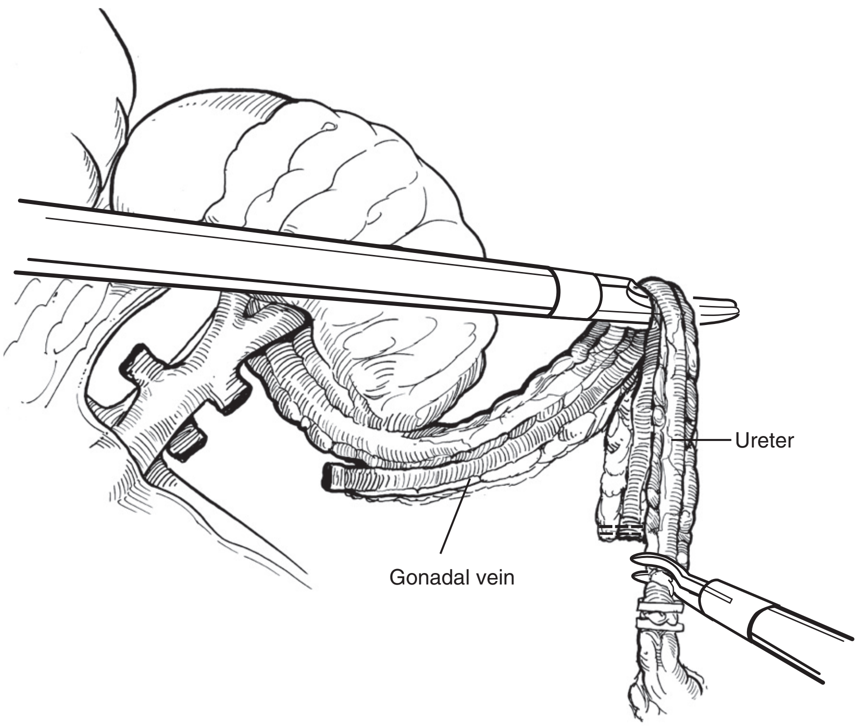


FIGURE 11–11. The gonadal vein is dissected laterally with the ureter, preserving the periureteral blood supply. The gonadal artery is divided as it crosses over the ureter near the iliac vessels. A clip is placed on the distal ureter, and the ureter is divided.

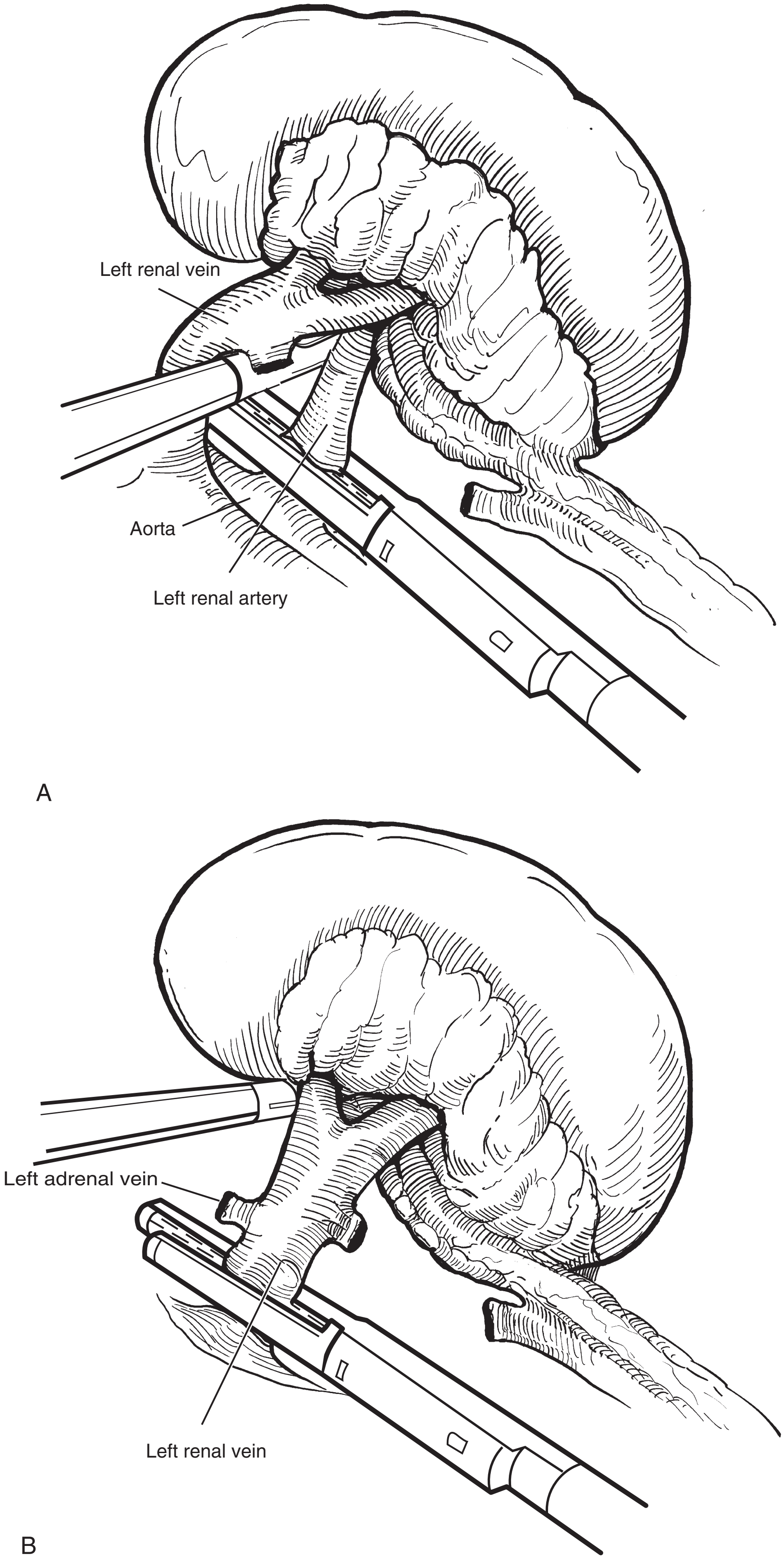


FIGURE 11–12. Endovascular GIA stapling and transection of proximal renal artery (*A*) followed by stapling and transection of main renal vein (*B*).

TABLE 11–1. SUMMARY OF MAJOR COMPLICATIONS FOLLOWING LAPAROSCOPIC DONOR NEPHRECTOMY

COMPLICATION	JACOBS ET AL[3] (%)	RATNER ET AL[2] (%)
Mortality	0 (0)	0 (0)
Open conversion	12 (1.6)	3 (1.7)
Blood transfusion	(1.2)	6 (3.4)
Vascular injury (major)	13 (1.8)	—
Bowel injury	2 (0.3)	1 (0.6)

Once pain is controlled with oral medication, diet is tolerated, and a successful voiding trial is passed, the patient is discharged from the hospital. The patient is evaluated in the clinic within a few weeks of discharge for a postoperative check.

COMPLICATIONS

Major operative complications following LDN at high-volume institutions are summarized in Table 11–1. Jacobs and associates[3] reviewed their 6-year experience of 738 LDNs, and Ratner and colleagues[2] described complications following their first 175 LDNs. Although less morbid than ODN, major operative complications do occur during LDN, and a thorough preoperative discussion with informed consent is imperative when reviewing the procedure with the anticipated donor. Operative complications, such as splenic laceration, pneumothorax, stapler misfires, and difficulties with specimen extraction, may occur. Postoperatively, cases of small bowel obstruction, pancreatitis, retroperitoneal hematoma formation, superficial wound infection, pulmonary atelectasis, and ileus and transient paresthesias have been reported.

Tips and Tricks

- The operative table should function properly with mechanical adjustments available, especially the “break” in the table over which the patient’s flank will be positioned. This ensures that laparoscopic instruments will not be restricted by the lower edge of the table.
- This mark will help guide the location of the lower incision made for hand placement and kidney extraction.
- Placing the laparoscopic lens into warm saline before insertion into the peritoneal cavity not only cleans the lens but also maintains constant temperatures of the metal to aid in prevention of lens fogging.
- Self-retaining retraction devices allow the surgeon and assistant surgeon to maximize trocar use for safe dissection. Alternatively, the camera may be secured to a robotic device for additional assistance.
- Variants in lumbar vein insertion are common, and traumatic dissection may result in troublesome lumbar vein bleeding.
- Should complications arise during the recipient’s surgical procedure and the transplantation aborted, then no injury has occurred to the ureter and a complicated repair is avoided.
- This is the critical event of the procedure. It is optimal to have nursing and support staff present who are familiar with laparoscopy and this procedure in particular. Shift change or operative “breaks” are discouraged immediately before and during these final maneuvers.

ACKNOWLEDGMENTS

We would like to acknowledge John M. Taylor (Biomedical Technician) for his assistance with acquiring and processing the intraoperative images and Robin Franklin for her creative assistance with the line drawings.

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CHAPTER 12

Laparoscopic Evaluation and Treatment of Symptomatic and Indeterminate Renal Cysts

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Michael D. Fabrizio

Renal cysts are a common finding and increase in incidence as patients age.[1] With the increasing availability of radiologic imaging and technological refinements in image quality, more and more incidental renal lesions are being detected. The majority of cysts require no surgical intervention; however, certain circumstances may mandate exploration, marsupialization, or extirpation. The most common classification scheme used to guide management of renal cysts was devised by Bosniak (Table 12–1, Fig. 12–1).[2,3] Unfortunately, imaging studies are not always diagnostic, and a low negative predictive value and potential for track seeding preclude routine needle biopsy when confronted with an indeterminate renal cyst.[4,5] Additionally, some patients may present with signs and symptoms, such as pain, infection, and obstruction, that are related to simple-appearing renal cysts.

Often, percutaneous drainage and sclerotherapy represent first-line therapy for symptomatic renal cysts. In the past, when a symptomatic renal cyst recurred, the urologist was left with the option of either repeating a percutaneous drainage procedure or proceeding with open surgical techniques. Subsequently, in the early 1990s, several minimally invasive methods were described, including retrograde endoscopic marsupialization and fulguration, percutaneous resection, and laparoscopic techniques.[6,7] In 1993, Rubenstein and colleagues[8] reported a series of 10 patients with chronic pain attributed to renal cysts and concluded that laparoscopic ablation is a safe and effective alternative to open surgery in patients for whom conservative measures had failed. More recently, Yoder and Wolf[9] reported symptom relief in 78% of patients undergoing laparoscopic decortication of peripheral and peripelvic renal and adrenal cysts.

INDICATIONS AND CONTRAINDICATIONS

Consider laparoscopic cyst decortication in patients with symptomatic simple renal cysts. A trial of percutaneous aspiration and sclerosis is not unreasonable in patients with exophytic cysts, but this therapy is not always efficacious and can pose a significant risk for fibrosis when used for perihilar cysts.[10–12] Renal cysts may also obstruct the collecting system, compress normal renal parenchyma, or spontaneously hemorrhage, often inducing pain or even hematuria. They also may become infected or cause obstructive uropathy or hypertension. The laparoscopic approach offers a minimally invasive approach to decompress cysts under direct vision and control. Patients with large renal cysts (>3 cm) may experience pain at some point; consider those patients who have not responded to more conservative therapies candidates for laparoscopic cyst decortication.

Also consider patients who have autosomal dominant polycystic kidney disease to be candidates for cyst decortication. Laparoscopic renal cyst marsupialization, decortication, and unroofing have been successful in providing long-term pain relief in patients with autosomal dominant polycystic kidney disease and are a useful adjunct in the treatment of this complication of the disease process.[13,14]

Patients with enhancing, solid components to their cysts (Bosniak classification IV) are not good candidates for cyst decortication. These patients are better served with partial or radical nephrectomy because the likelihood of malignancy must mandate a true cancer operation.

Cautiously approach intraparenchymal cysts because locating and removing these cysts laparoscopically can be difficult. There is also an increased danger of injury to the collecting system and a risk of significant bleeding.

PATIENT PREOPERATIVE EVALUATION AND PREPARATION

To prepare for surgery, all patients undergo routine laboratory and radiographic studies as indicated. Evaluate the renal lesion by reviewing the patient's three-phase renal computed tomography (CT) scan with precontrast, nephrogram, and delayed images. In patients with a contraindication to contrast administration, magnetic resonance imaging is an acceptable alternative.

TABLE 12–1. RENAL CYST CLASSIFICATION BASED ON BOSNIAK CRITERIA

Type	Wall	Septations	Calcification	Precontrast Density (HU)	Enhancement
I	Thin	None	None	0–20	None
II	Thin	None to few	Minimal	0–20	None
III	Increasing thickness	Multiple	Moderate	0–20	None
IV	Thick	Many	Coarse	>20	Yes

Data from Bosniak M: The current radiological approach to renal cysts. Radiology 158:1–10, 1986.

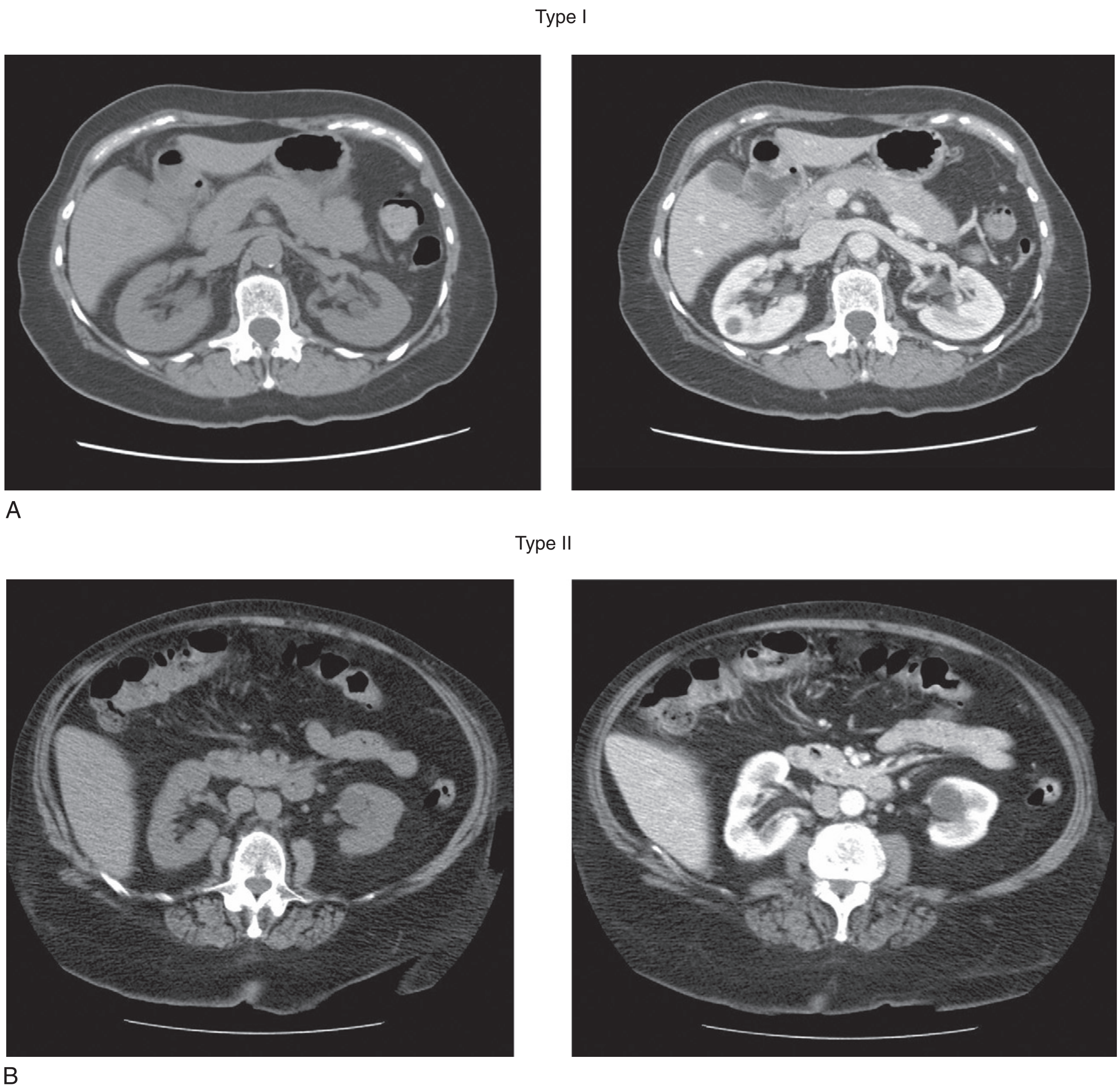
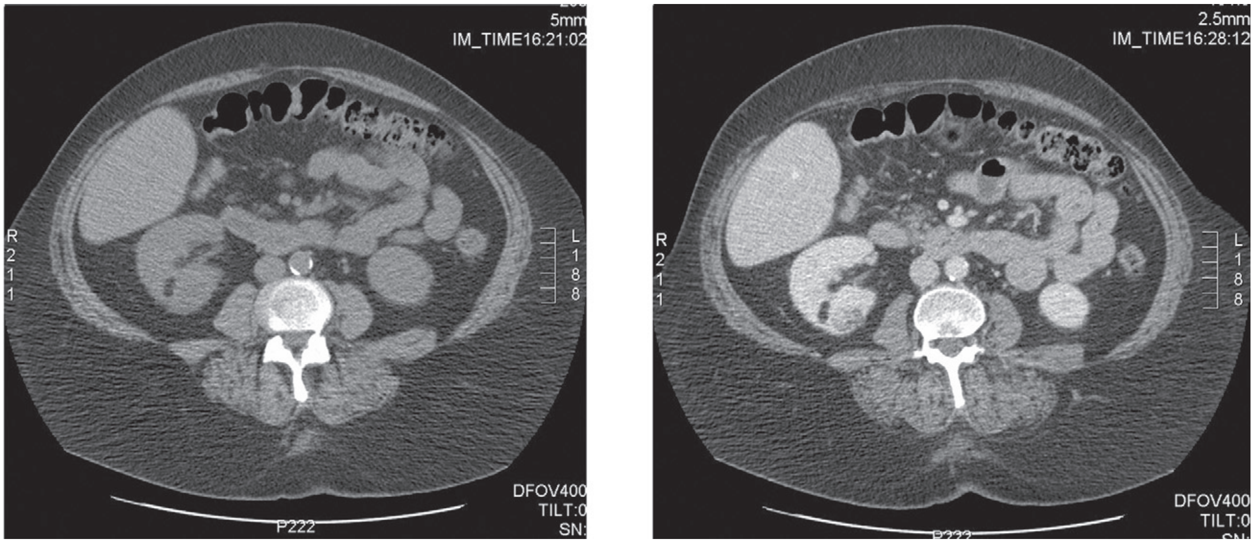


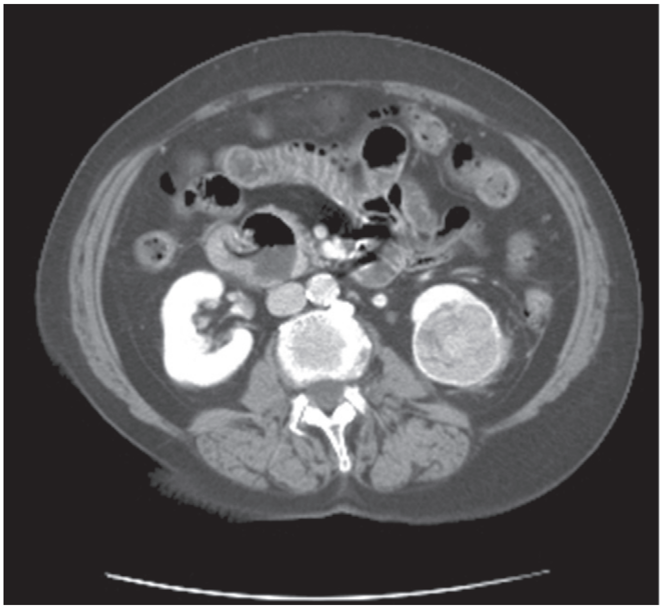
FIGURE 12–1. Precontrast and postcontrast images of the different classifications of Bosniak cystic lesions. *A,* Type I—simple benign cysts. *B,* Type II—benign cystic lesions that are minimally complicated; thin (less than 1 mm), smooth septa without associated thickened elements.

Type III



C

Type IV



D

FIGURE 12–1, cont'd. *C,* Type III—more-complicated cystic lesions exhibiting some findings observed with malignant lesions; irregularity of the septum wall, thickness greater than 1 mm, or solid area at wall attachments; evidence of solid tissue within the cyst wall or of extrinsic compression of the wall by a mass. *D*, Type IV—lesions that are clearly malignant; multiple septa, very irregular septa, and associated solid areas; presence of enhancing soft tissue mass.

Continued

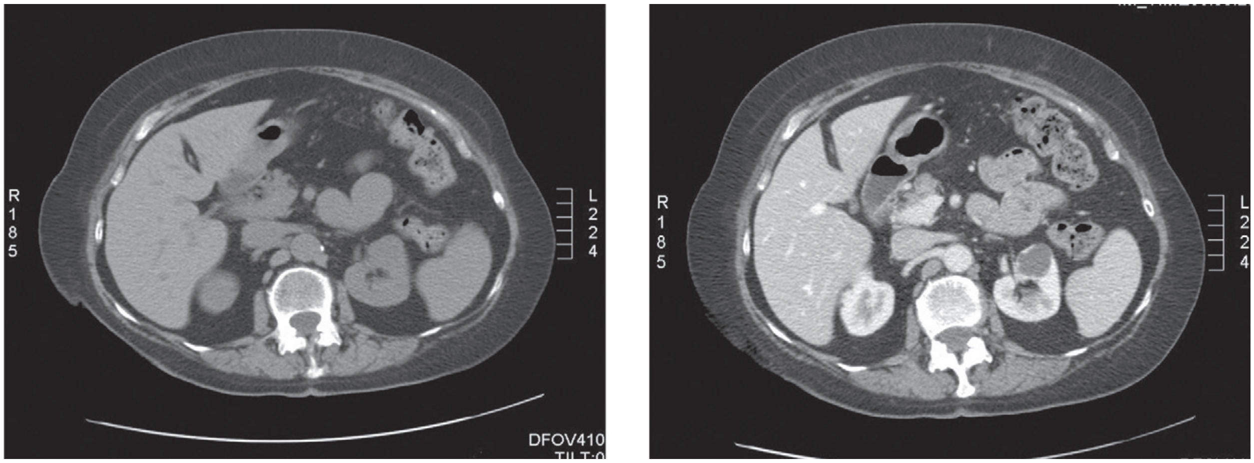
Preoperatively, counsel patients extensively that a technically successful cyst decortication does not guarantee resolution of their symptoms. Additionally, inform all patients that if malignancy is suspected or detected, more extensive resection may be performed, such as simple enucleation, partial nephrectomy, or radical nephrectomy.

A preoperative bowel preparation regimen is not routinely administered, but prophylactic antibiotics are administered 1 hour before the procedure. After induction of general anesthesia, place a Foley catheter in the bladder and position an orogastric tube, where it remains until the completion of the procedure. If the cyst is clearly peripheral and does not involve the collecting system, a ureteral stent or catheter is not necessary. However, if there is any question that a cyst may be near the collecting system, place an open-ended ureteral catheter at the time of surgery before patient positioning. Secure this ureteral catheter to the Foley catheter and use it to instill methylene blue intraoperatively to evaluate the integrity of the collecting system after cyst excision.

OPERATING ROOM CONFIGURATION AND PATIENT POSITIONING

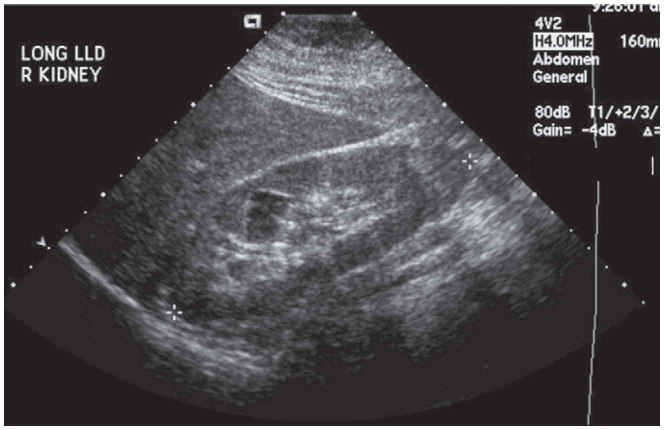
The operating room configuration for both the transperitoneal and retroperitoneal approaches allows all members of the operating room team to observe the procedure. For a transabdominal procedure, set up the operating room so that the surgeon and assistant surgeon are on the contralateral side of the renal

Type IIF



E

Type IIF



F

FIGURE 12–1, cont'd. *E*, Indeterminate lesions between types II and III; classified in type IIF (for "follow-up"). *F,* Ultrasound image of type IIF and computed tomography scan of type IIF (*E*).

cyst. For a retroperitoneal approach, set up the operating room so that the surgeon stands behind the patient (Fig. 12–2).

Patient positioning depends on the type of approach used; retroperitoneal and transperitoneal approaches require a similar setup. For patients with cysts located in the anterior portion of the kidney, use a transperitoneal approach (Fig. 12–3). In obese patients, a more lateral position may allow the pannus to fall medially, thus providing better exposure to the ipsilateral side. Posterior lesions may be easier to approach through the retroperitoneum (Fig. 12–4). Once the patient is in position and all of the securing straps have been applied, it is imperative to completely airplane the bed in both directions before draping to ensure that the patient remains secure at the extremes of table position.

TROCAR PLACEMENT

Transperitoneal Approach

After the entire abdomen is prepared and draped in a sterile fashion, establish pneumoperitoneum using a Veress needle or via a Hasson technique. The trocar placements are mirror images for left and right renal cysts. Place the first trocar using a visual obturator just lateral to the rectus muscle at the level of the umbilicus (Fig. 12–5). Place the remaining ports under direct vision once access to the intra-abdominal space is obtained. Place each trocar with the port valves facing opposite the direction of surgery; this allows maximal mobility of the trocar when the working instruments are being used. If the 10/12-mm ports are to be closed at the completion of the surgery, preplace the 2-0 Vicryl sutures using the Carter-Thomason device and leave the sutures untied.

A fourth port is often necessary to retract the liver or spleen to provide exposure to the upper pole of the kidney. Place a 3-mm port superior to the mid-epigastric port to pass a 2-mm grasper under the liver or spleen to the side wall to safely elevate the organ and facilitate retraction. Alternatively, place a 5-mm port lateral to the 10/12 midclavicular port, which is used to pass a Diamond Flex retractor for liver and spleen retraction.

Obese patients often require a more lateral port placement to access all portions of the kidney. Usually, shift the umbilical and lateral ports directly lateral from the umbilicus and lateral to the rectus muscle. Shift the superior midline port to remain in line with the 10/12-mm port site.

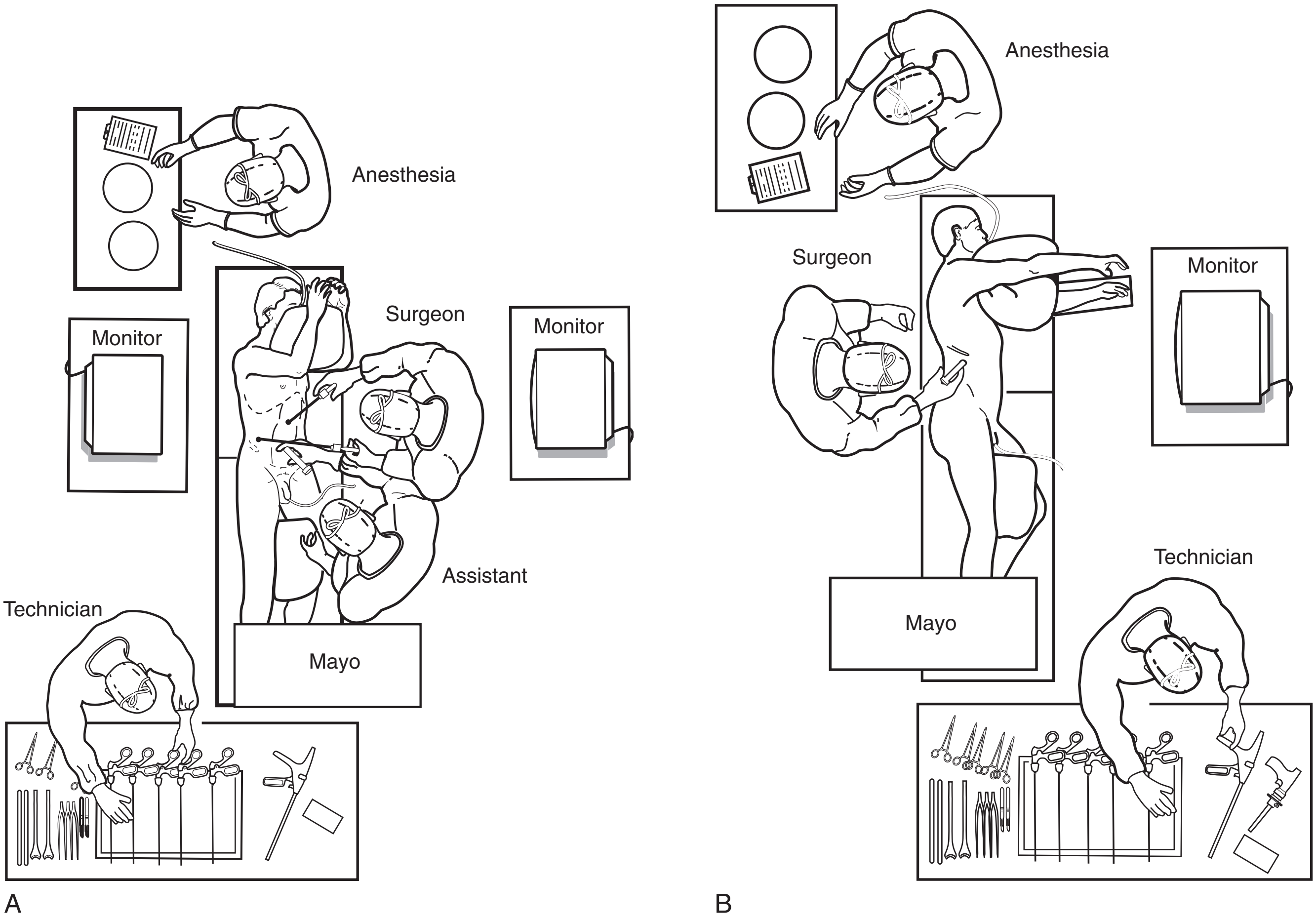


FIGURE 12–2. *A,* For a transabdominal procedure, the operating room is set up so that the surgeon and assistant are on the contralateral side of the renal cyst. *B,* For a retroperitoneal approach, the operating room is set up so that the surgeon stands behind the patient.

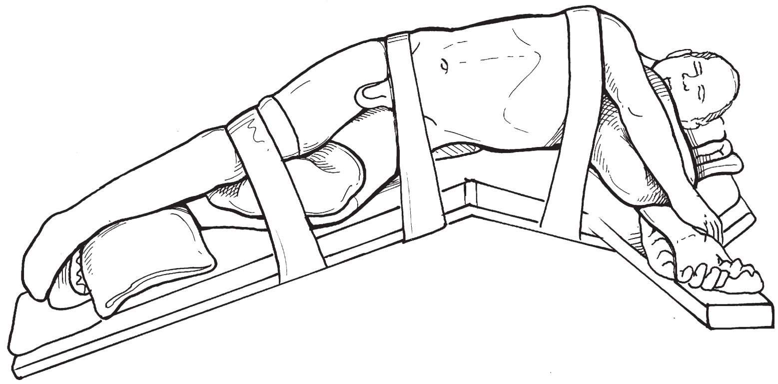


FIGURE 12–3. For a transperitoneal approach, the patient is placed in a modified 45-degree flank position and a roll of sheets is placed behind the back to support the scapula and shoulder. The hips are in a more anteroposterior (upright) position. An axillary roll is placed if necessary. Sequential pneumatic compression devices are applied, and the legs are padded and secured to the table with a safety strap. The arms can be folded across a pillow on the chest or the upper arm can be propped up by an elevated arm support attached to the bed. The table is flexed to open up the space between the rib cage and iliac crest on the ipsilateral side.

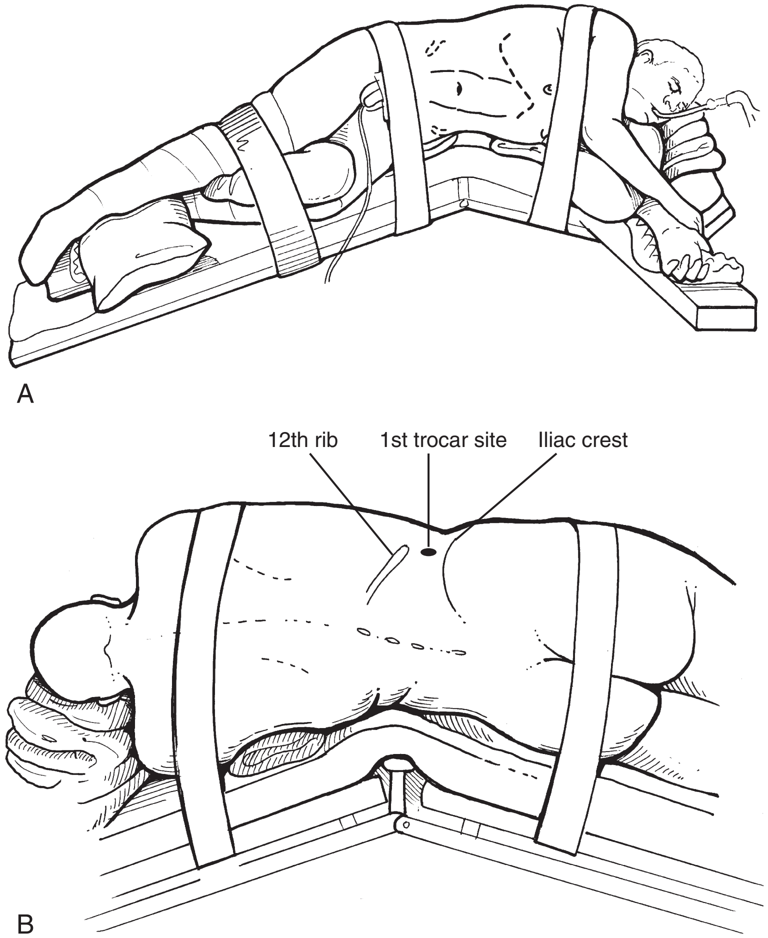


FIGURE 12–4. *A,* For a retroperitoneal approach, the patient is placed in the full flank position with the lower leg flexed and the upper leg straight. An axillary roll is used, and the lower arm is placed on an arm board. The upper arm can be flexed across a pillow or placed on an elevated arm support. *B,* The kidney rest is elevated and the table is flexed. The patient is secured to the table with padded straps along the hips and upper extremities.

Retroperitoneal Approach

Typically, use three trocars for a retroperitoneal approach. The first is a 10/12-mm trocar placed in the posterior axillary line halfway between the iliac crest and the tip of the 12th rib (Fig. 12–6). After dissecting a space in the retroperitoneum and sweeping the peritoneum medially, place the second 10/12-mm trocar in the anterior axillary line under direct vision. Place a third, 5-mm, trocar superiorly, above the 10/12-mm trocar in the anterior axillary line. Avoid placing this trocar in a supracostal location because this may lead to inadvertent entry into the pleural space.

PROCEDURE

Transperitoneal Approach

After trocar placement, rotate the patient maximally toward the surgeon. On the left side, reflect the descending colon medially from the splenic flexure to the level of the sigmoid entering the pelvis. At the level of the spleen, divide the phrenocolic, lienorenal, and splenocolic ligaments (Fig. 12–7). On the right side, reflect the colon along the line of Toldt to the cecum (Fig. 12–8). Perform this with sharp and blunt dissection using electrocautery as necessary. It may be necessary to use an instrument to facilitate liver retraction. Divide the colorenal ligaments. Be cautious not to injure the duodenum during division of the medial attachments. For interpolar or medial lesions, perform a Kocher maneuver to provide excellent exposure (Fig. 12–9). Do this with a combination of sharp and blunt dissection while avoiding cautery in the vicinity of the duodenum. If the correct planes are dissected, there is minimal bleeding.

Once the colorenal ligaments have been divided, Gerota's fascia can be seen. Often, the renal cyst is easily seen at this point and looks like a well-defined blue dome protruding from the surface of the kidney (Fig. 12–10). If it is difficult to identify the cyst location or if there is concern that the mass is not a simple cyst, perform intraoperative ultrasonography (US) using a laparoscopic probe to locate and further characterize the lesion. After visual inspection, aspirate the cyst through the 5-mm port using a laparoscopic needle (Fig. 12–11), and send the fluid for cytologic and chemical analysis.

After aspiration, excise the cyst wall with laparoscopic scissors at its junction with the parenchyma and send it for pathologic evaluation (Fig. 12–12). Due to the possibility of malignancy, remove the specimen via a laparoscopic bag device. It is also possible to send the cyst wall for frozen section. Obtain biopsy samples from the base of the cyst using the 5-mm laparoscopic biopsy forceps (Fig. 12–13). Fulgurate the base of the

Text continued on page 151

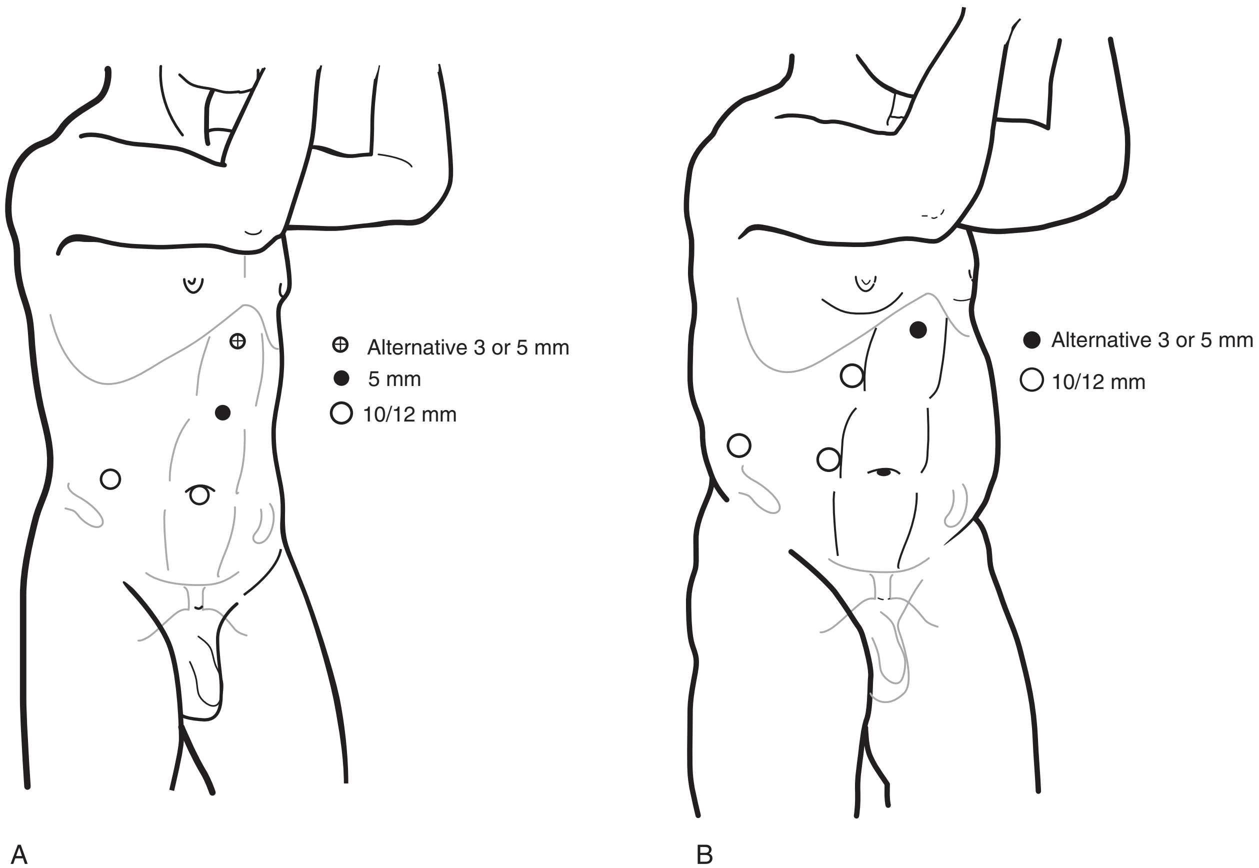


FIGURE 12–5. *A,* In a transabdominal approach, three trocars are used. The first 10/12-mm port is placed lateral to the rectus muscle at the level of the umbilicus. A second 10/12-mm port is placed at the umbilicus, and this is used for the 30-degree lens. The third port is a 5-mm port placed in the midline halfway between the umbilicus and xyphoid. *B*, In obese patients, the ports are shifted laterally.

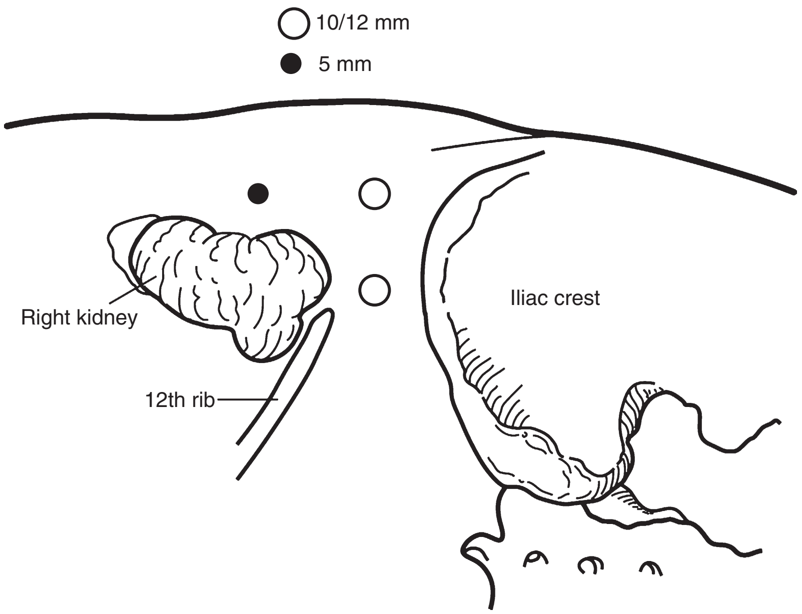


FIGURE 12–6. Typical port placement for the retroperitoneal approach.

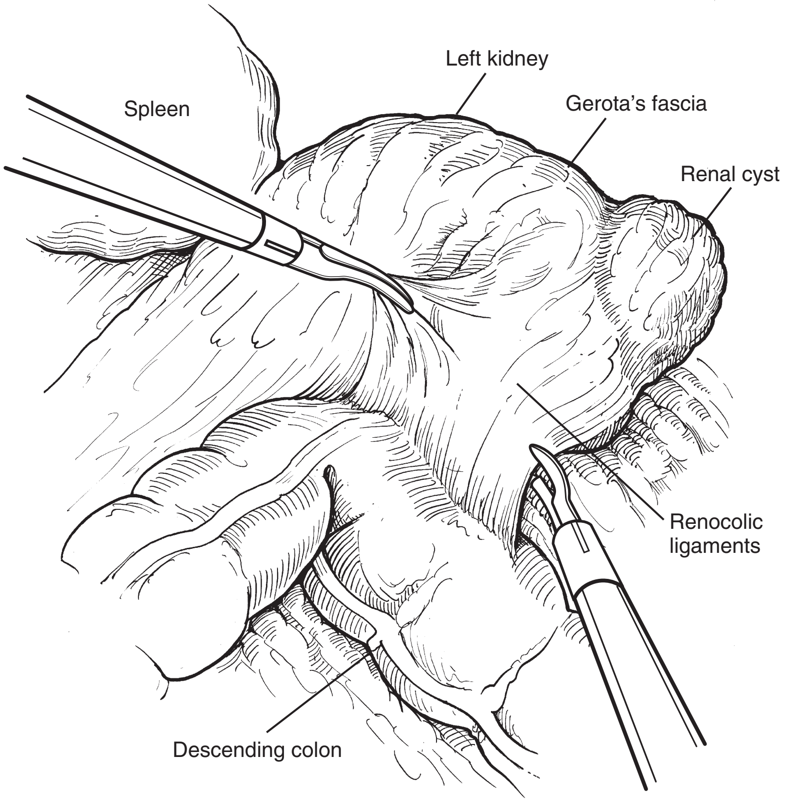


FIGURE 12–7. Division of the phrenocolic, lienorenal, and splenocolic ligaments on a left-sided dissection.

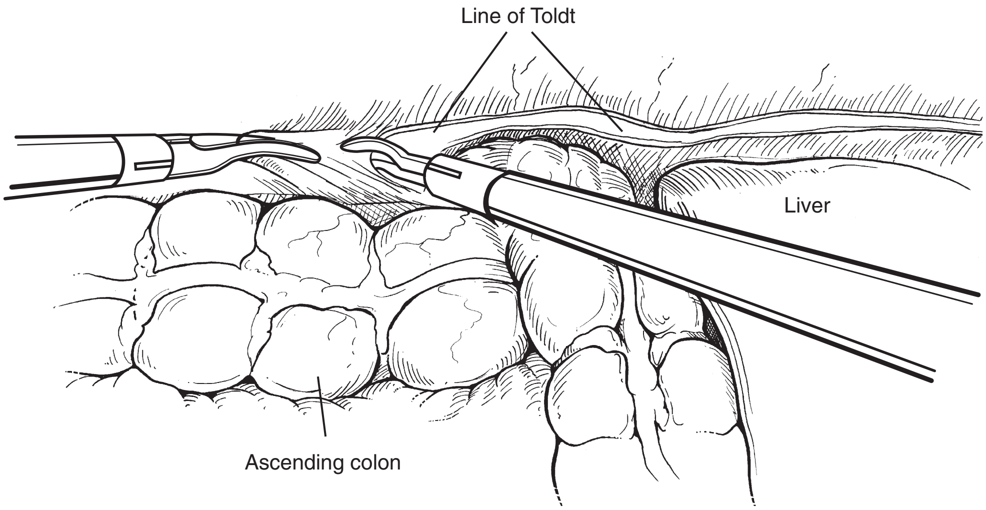


FIGURE 12–8. Incision of the white line of Toldt and reflection of the hepatic flexure of the colon.

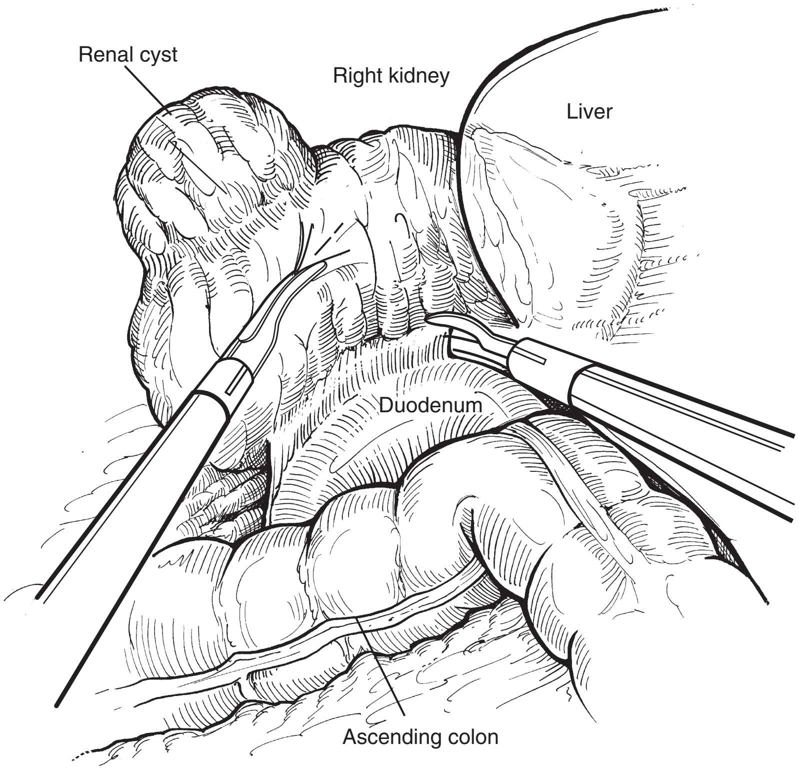


FIGURE 12–9. On the right side, the colon is reflected and a Kocher maneuver may be necessary to expose the kidney.

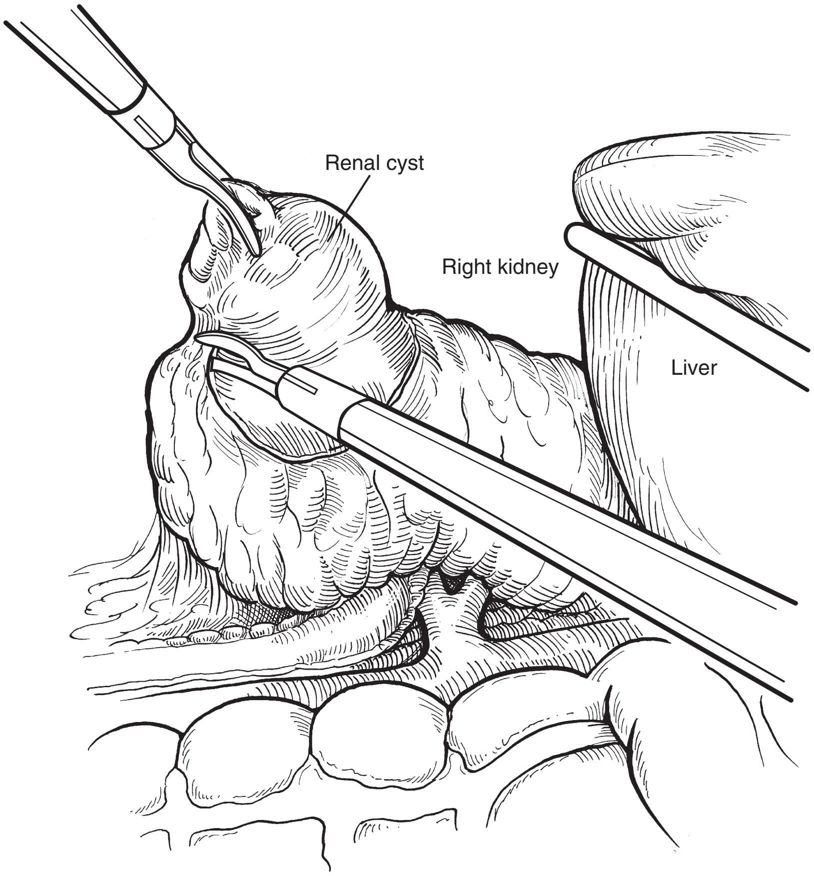


FIGURE 12–10. The cyst is located after reflecting the bowel and incising Gerota's fascia. A laparoscopic ultrasound probe may be needed to locate small or intraparenchymal cysts.

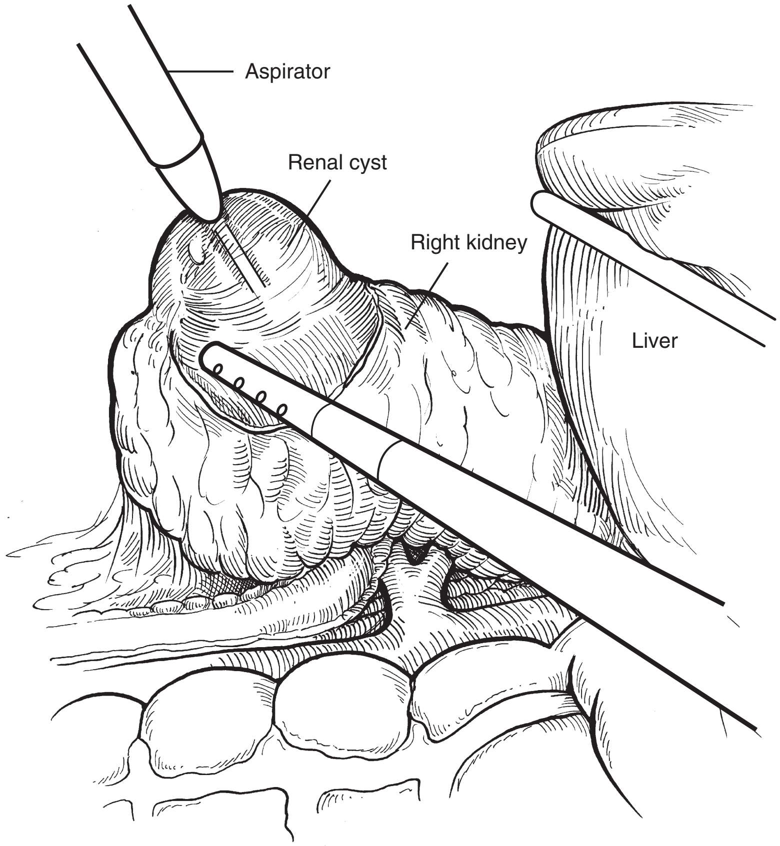


FIGURE 12–11. After visual inspection, the cyst is aspirated through the 5-mm port by means of a laparoscopic cyst aspiration needle (aspirator).

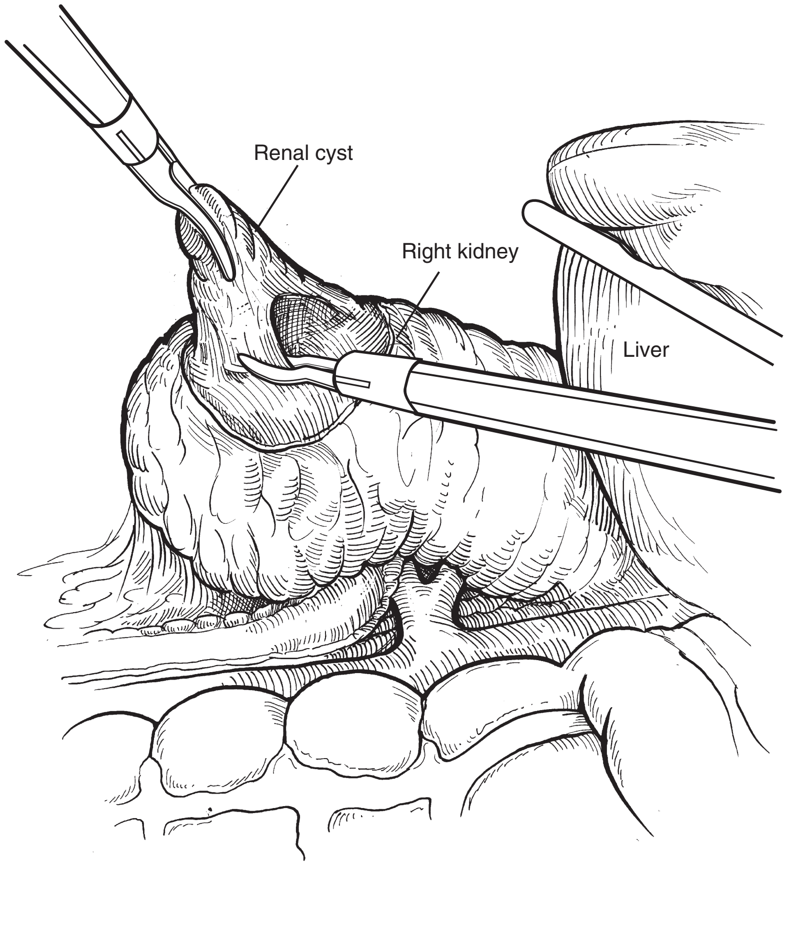


FIGURE 12–12. The cyst wall is elevated with a grasper, and scissors are used to circumferentially excise the cyst wall.

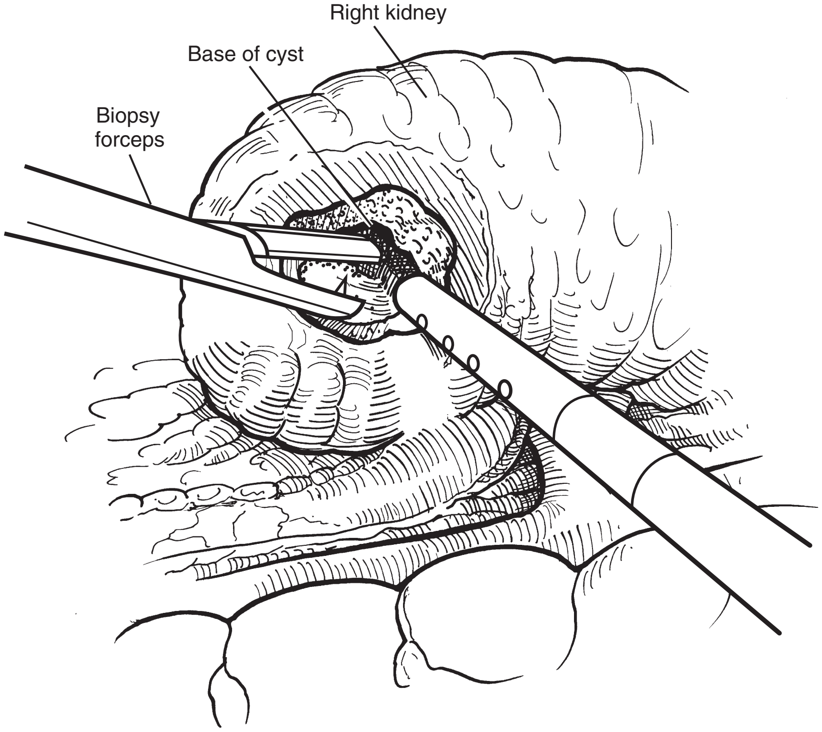


FIGURE 12–13. The base of the cyst is carefully inspected, and biopsy samples are obtained with laparoscopic biopsy forceps.

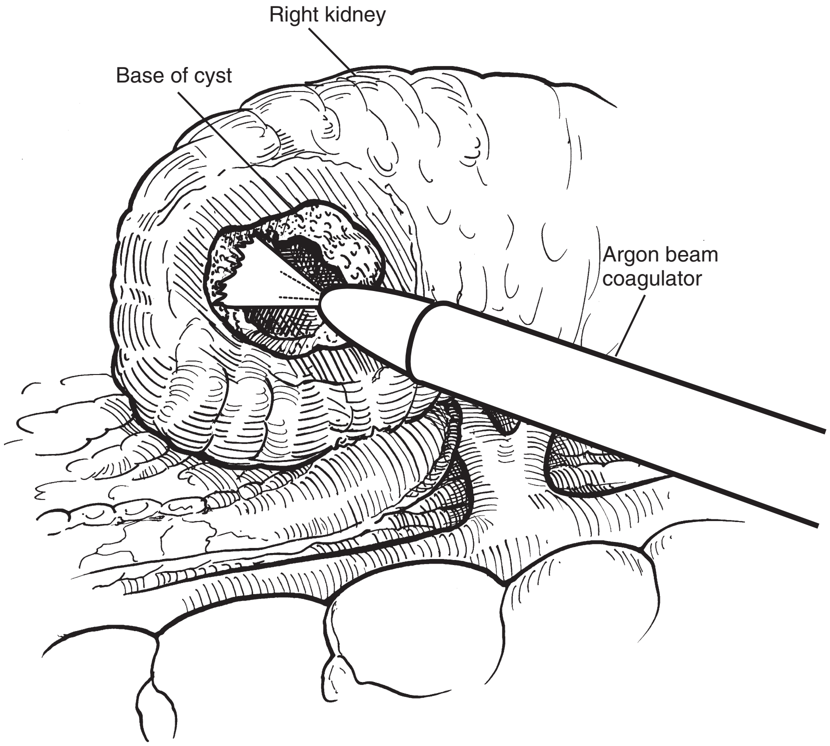


FIGURE 12–14. Argon beam coagulation is used at the cyst base.

cyst with the argon beam coagulator (Fig. 12–14), and place surgical cellulose (e.g., Surgicel, Johnson & Johnson, Inc., Arlington, TX) in the cavity. Take care to avoid inadvertent entry into the collecting system. If injury is suspected, confirm it using retrograde installation of methylene blue through the ureteral catheter. If the collecting system is entered, close it using standard suturing techniques and place a drain either through the lateral port site or via a separate stab incision at the completion of the case (Fig. 12–15). Again, place Surgicel in the cavity, and apply additional fibrin sealant, if needed, to ensure hemostasis and prevent leaks. Bring the colon over the kidney and attach it to the side wall to "re-retroperitonealize" the kidney and drain (Fig. 12–16). If there is no collecting system entry, a drain is not necessary.

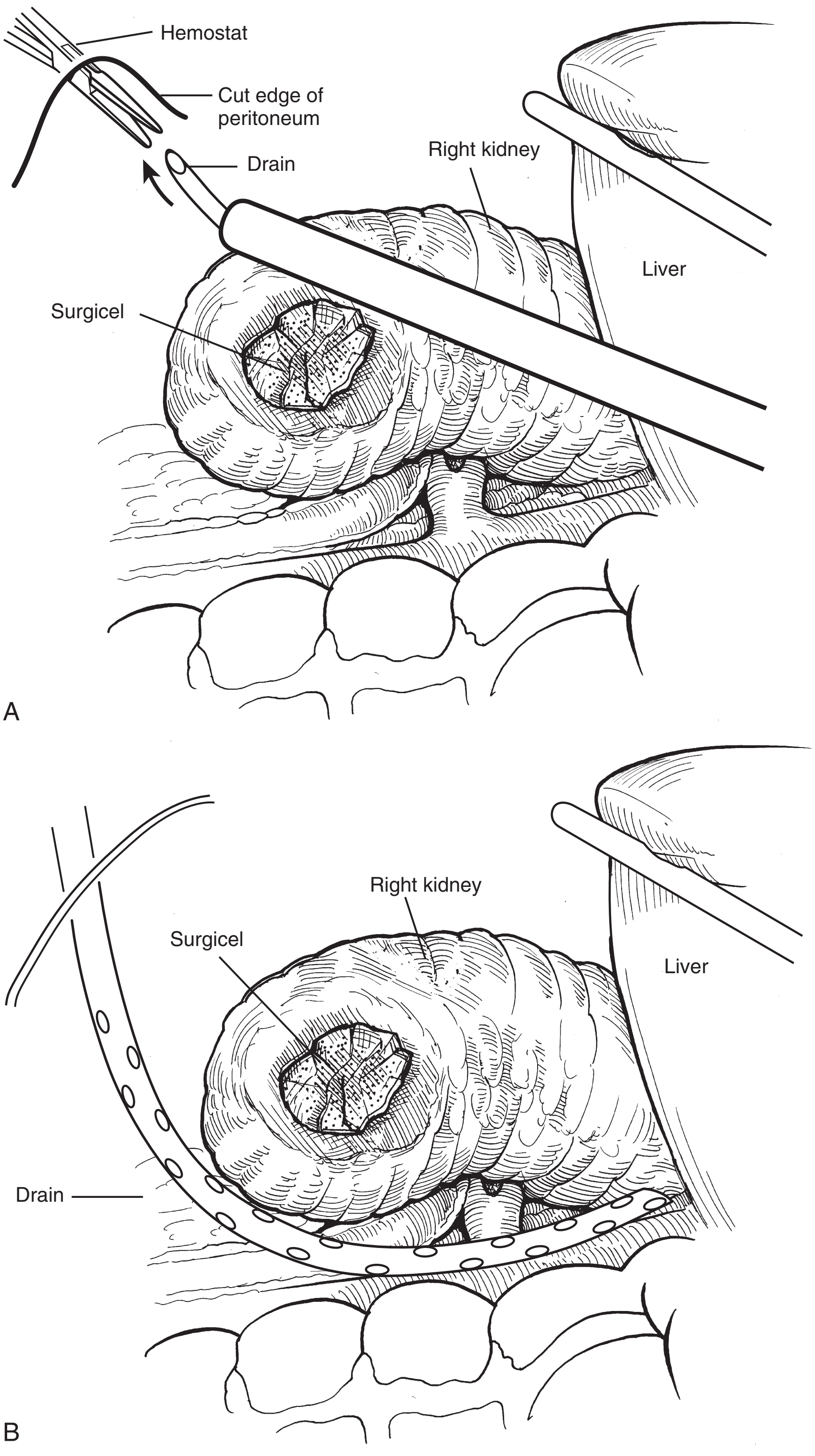


FIGURE 12–15. *A*, A drain is placed by passing a hemostat through a separate stab incision and grasping a drain that has been inserted via one of the ports. *B*, The drain is placed in a dependent position, and excess length is trimmed and removed.

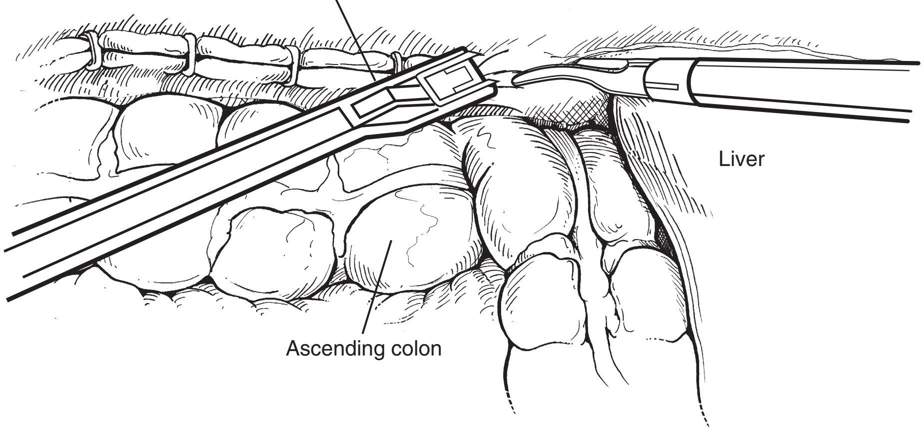


FIGURE 12–16. The colon is reattached to the side wall using hernia staples or free suture.

If malignancy is suspected upon visualization of the lesion or proven by frozen section, perform a partial or radical nephrectomy. The patient must be made aware of this possibility at the time of preoperative counseling.

Retroperitoneal Approach

Once access to the retroperitoneal space is obtained as described previously, identify the psoas and quadratus muscles and incise Gerota's fascia using laparoscopic scissors. This approach allows excellent access to the posterior surfaces of the kidney where the cyst is visualized. Intraoperative US can be helpful in locating deep cysts or in further characterizing suspicious cysts. Once the cyst is identified and isolated, the excision is essentially the same as in the transperitoneal approach.

POSTOPERATIVE MANAGEMENT

Postoperatively, two doses of a broad-spectrum, parenteral antibiotic are given routinely. If an external drain is left in place, continue the antibiotics and switch to oral administration. Patients begin a clear liquid diet on postoperative day 1, and this is advanced as tolerated. The Foley catheter is removed on the first postoperative day, and the patient is encouraged to ambulate. If there is any concern about an injury to the collecting system, the double J stent is left in place for 4 weeks. The external drain can be removed after the output is minimal or the fluid is shown to be other than urine (check fluid creatinine). This procedure is generally well tolerated and patients are often discharged to home on postoperative day 1 or 2. A repeat CT scan may be obtained in the postoperative period, but this is not required if the symptoms have resolved and no cancer was found in the specimen.

COMPLICATIONS

The complications of initial access and renal exposure in laparoscopic surgery are discussed in Chapter 28. In the postoperative period following cyst decortication, consider a urinoma in the differential diagnosis for a patient with fever (>38.5ºC), persistent ileus, abdominal pain, nausea, or an elevated white blood cell count with a left shift. CT scan with oral and intravenous contrast can be helpful in identifying a urine leak. If a leak is detected, reinsert the Foley catheter and place or reposition a stent as indicated. If a retroperitoneal drain was not left at the time of surgery, place it percutaneously using radiographic guidance.

Retroperitoneal hematomas can manifest postoperatively; typically, patients complain of significant abdominal pain and subsequently develop an ileus. Obtain complete blood cell counts as indicated. Conservatively treat the vast majority of patients with hematomas with bed rest and observation with other supportive measures, including transfusion. Rarely, arteriography is required to identify and treat a source of ongoing bleeding.

If the final pathologic examination of the specimen reveals cancer that was not suspected intraoperatively, it is best to perform definitive surgical therapy (radical or partial nephrectomy) within a week of the laparoscopic procedure. This may avoid a future difficult dissection through scarred tissues.

Tips and Tricks

- Perform a three-phase CT scan with precontrast, postcontrast, and delayed contrast views; this is the best way to characterize cystic lesions radiographically.
- Before surgical intervention, consider percutaneous cyst aspiration and sclerotherapy, which may provide prolonged relief for the patient.
- Treat all renal lesions as potentially malignant, and take care to remove all of the specimen (preferably in a collection bag device).
- Aspirate the cyst and send the fluid for cytology.
- Excise the cyst wall completely and send for histopathologic analysis.
- Use an argon beam coagulator to treat the cyst cavity.

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CHAPTER 13

Laparoscopic and Percutaneous Delivery of Renal Ablative Technology

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Jaime Landman

Technologic advances in minimally invasive surgery are revolutionizing the treatment of renal tumors. Laparoscopic radical nephrectomy is presently defined as a standard of care because it has been shown to be oncologically efficacious and safe. More recently, initial data have demonstrated that laparoscopic partial nephrectomy (LPN) is a minimally invasive nephron-sparing approach that is as effective in disease control as is open partial nephrectomy.[1] However, both open and laparoscopic partial nephrectomy have risks of bleeding and urine leak and can be associated with significant morbidity in the high-risk patient. Efforts to reduce the morbidity associated with LPN while preserving nephrons have generated an interest in renal ablative technologies.

With the introduction of liquid nitrogen– or argon-cooled probes, targeted renal cryoablation (CA) became clinically feasible.[2] Temperatures as low as −195.8°C can be produced, resulting in direct cell injury with intracellular ice crystal formation or secondarily by reperfusion injury during the thawing phase.[3] Histologically, coagulative necrosis is eventually replaced by fibrosis in the targeted tissue. Similarly, coagulative necrosis can also be accomplished by heating soft tissue to temperatures exceeding 60°C. Radiofrequency ablation (RFA) achieves temperatures of this range by delivering a monopolar electrical current via a needle electrode.[4] The first attempts at percutaneous CA were reported in 1995,[5] and Gill and associates[6] reported their initial series of laparoscopic renal CA in 1998. Zlotta and colleagues[7] reported the first percutaneous renal RFA in 1997, and laparoscopic RFA was first used clinically as a hemostatic measure preceding LPN.[8]

INDICATIONS AND CONTRAINDICATIONS

The indications for ablative procedures are similar to the indications for nephron-sparing surgery in general. Patients who have typically been candidates for radical nephrectomy are not generally considered candidates for ablative therapy. Patients with a small (<4 cm) contrast-enhancing renal mass or a complex renal cyst suspicious for renal cell carcinoma and imperative indications for nephron-sparing surgery (anatomically or functionally solitary kidney) are good candidates for ablative technologies. Relative indications occur in the presence of diseases that may impair the normal contralateral kidney, such as diabetes mellitus, hypertension, nephrolithiasis, and renal artery stenosis.

Patients with inherited diseases that have a propensity for multifocal and recurrent tumors, such as von Hippel–Lindau disease, are well suited for ablative procedures. In this patient population, the recurrent tumors can be treated in a minimally invasive manner on multiple occasions. In our experience, repeated laparoscopic treatment of tumors with CA is feasible because a laparoscopic approach causes minimal scarring.[9] Indeed, a percutaneous ablative approach will likely be even more easily repeatable, although definitive data are lacking.

Because long-term data about tumor ablation are lacking, patients with a shorter life expectancy, such as older patients with impaired performance status, are good candidates for ablative procedures. Younger patients are counseled regarding the lack of long-term data and undergo ablation only in highly selected situations.

Treatment of patients with centrally located renal tumors or with cystic lesions remains controversial. LPN is particularly challenging in patients with endophytic tumors. As such, ablative technologies, which can be targeted by imaging modalities, are ideally suited for these tumors. In the Columbia University experience, approximately one third of all tumors treated have been endophytic. With short follow-up, we have had excellent results. Management of cystic lesions has similarly been controversial.

Contraindications for laparoscopic ablative procedures include coagulopathy, history of peritonitis or multiple adhesions, or severe obstructive airway disease. Contraindications for percutaneous ablative procedures include the presence of overlying structures such as bowel, liver, or spleen that interfere with probe placement.[4] In general, tumors within 1 cm of bowel structures, the ureteropelvic junction, or the hilar vasculature are contraindicated. These tumors are more safely approached laparoscopically to allow for mobilization of these sensitive structures to protect them during tumor ablation.

PATIENT PREOPERATIVE EVALUATION AND PREPARATION

After having a full discussion of the risks and benefits of this procedure with the patient, have him or her sign an informed consent form. A bowel preparation, including a clear liquid diet and one bottle of magnesium citrate the day before surgery, is recommended. Routine serum hematology, chemistries, liver function, coagulation studies, and a type and screen are per-

formed. A standard metastatic evaluation including a chest radiograph is performed. One gram of cefazolin is administered intravenously, and sequential compression devices are placed on the lower extremities preoperatively.

Review a computed tomography (CT) scan or magnetic resonance imaging (MRI) with and without intravenous contrast. For percutaneous procedures, the imaging study is taken with the patient in the prone or flank position to reveal exact intra-abdominal organ position when probe placement is attempted. Choose either a transperitoneal or retroperitoneal laparoscopic approach based on tumor location, patient's surgical history, and preference.

High-quality recent (within 3 months) axial imaging is an important part of preoperative preparation. For laparoscopic procedures, axial imaging studies can help expedite identification of the tumor. Additionally, probe targeting is critically important and is greatly facilitated by high-quality imaging; probe deployment can be optimized by coordinating the gestalt picture of the laparoscopic view, the laparoscopic ultrasound (US) image, and the preoperative imaging.

OPERATING ROOM CONFIGURATION AND PATIENT POSITIONING

For laparoscopic procedures, position the monitor on the opposite side of the patient from the surgeon. The insufflation pressure and CO_2 flow rate should be easily visible by the surgeon. The scrub nurse stands beside the surgeon. The equipment specific to the ablation procedure is best positioned at the foot of the patient, allowing these connections to pass perpendicular and over the top of the cords from the monitor tower. The same considerations apply for percutaneous procedures. With the patient prone, stand on the same side as the lesion and, ideally, have a straight-line view of the imaging monitor. The anesthesiologist occupies the room at the head of the patient, leaving room at the foot of the patient for ablation equipment (Fig. 13–1).

For laparoscopic transperitoneal procedures, position the patient in a 70-degree flank position with the patient's ventral surface aligned with the edge of the operating table. For retroperitoneal procedures, use a 90-degree flank position, typically, with the patient centered in the middle of the operative table. With the patient's iliac crest at the break in the table, flex the table. Flex the contralateral knee. Place an axillary roll, and carefully pad all pressure points. Position the arms to prevent brachial plexus tension (Fig. 13–2). After the patient is adequately positioned, secure the patient to the table at the chest, hip, and knee in case rotation of the table is needed during the procedure. For percutaneous procedures, place the patient in the prone position.

TROCAR PLACEMENT

Laparoscopic ablative technology can be applied via a transperitoneal or retroperitoneal approach. Anterior renal tumors are best approached transperitoneally, whereas posterior tumors

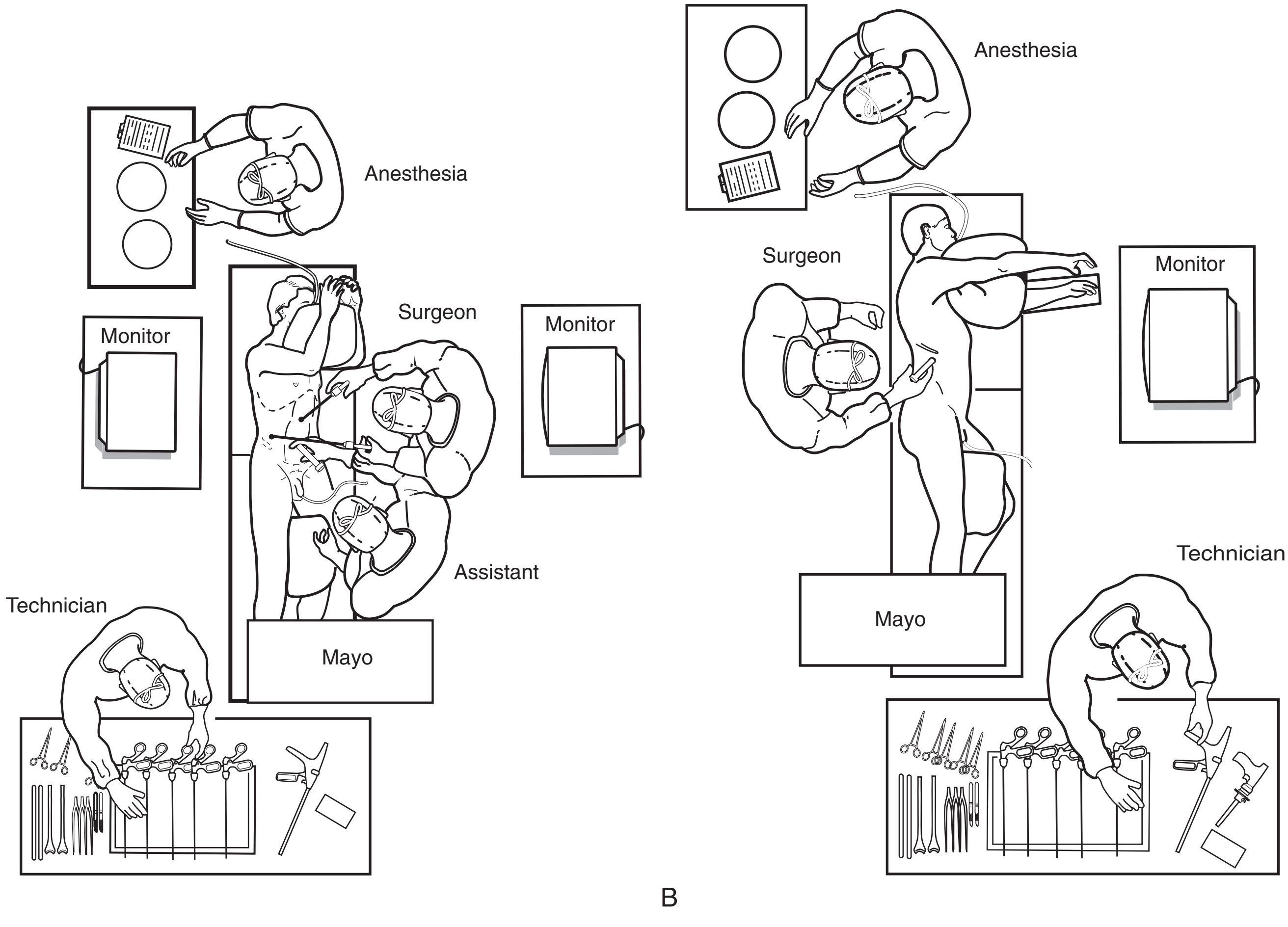

FIGURE 13–1. Operating room configuration for (*A*) transperitoneal approach and (*B*) retroperitoneal approach.

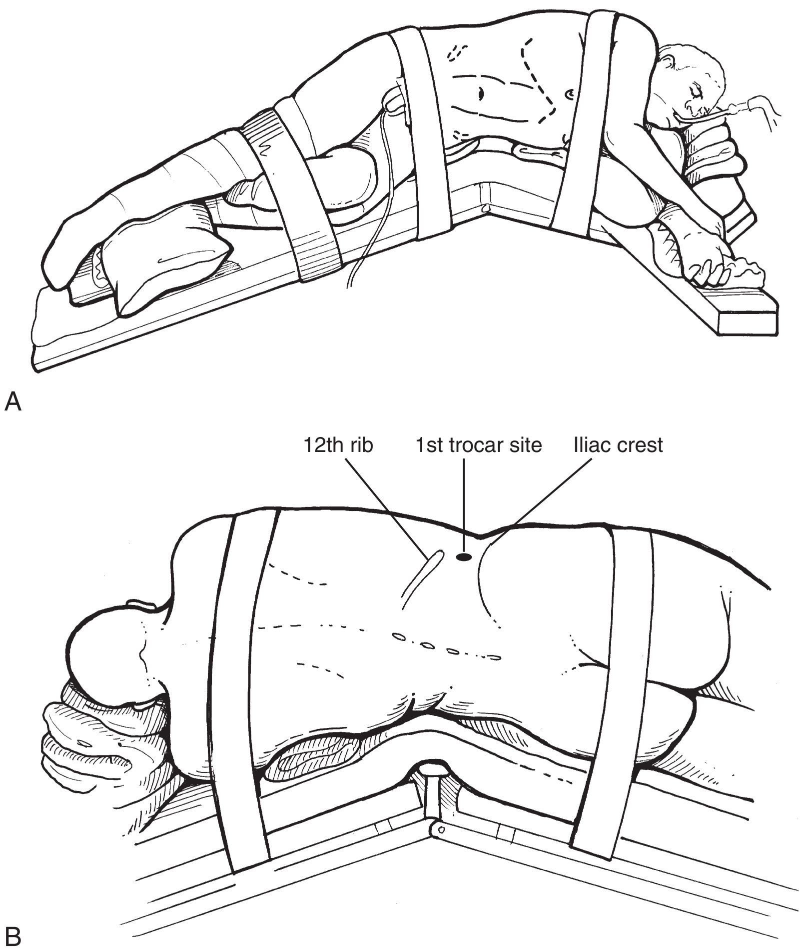

FIGURE 13–2. *A,* Patient positioned for a transperitoneal approach. *B,* Patient positioned for a retroperitoneal approach.

are accessed retroperitoneally. Preference dictates the approach for lateral tumors. However, imposing the wrong approach results in the need for additional renal mobilization and can result in suboptimal angles of ablation. Whenever possible, treat anterior tumors with a transperitoneal approach and treat posterior tumors with a retroperitoneal approach (Fig. 13–3).

A template for transperitoneal renal surgery trocar positions is presented in Figure 13–4. With no history of abdominal surgery, place a Veress needle, if needed, at the anterior superior iliac spine trocar site to establish a pneumoperitoneum of 15 mm Hg. If there has been prior lower abdominal surgery, obtain initial access at the subcostal trocar site. Place the lower trocar approximately 1 inch medial and superior to the anterior superior iliac spine, and place the subcostal trocar in the midclavicular line. Use a visual dilating trocar with a 0-degree lens for optimal initial trocar placement. Subsequently, introduce the remaining trocars under laparoscopic vision via the initial trocar site. Place the third trocar at the umbilicus; this trocar serves as the primary access site for the laparoscope. Place an optional fourth 5-mm trocar at the posterior axillary line, if needed, to optimize tumor position for probe entry or, for right-sided tumors, place the trocar just inferior to the xyphoid to introduce a locking grasper for liver retraction. Shift transperitoneal trocar positions laterally for obese patients or cephalad for upper pole tumors.

Figure 13–5 demonstrates a suggested trocar template for retroperitoneal surgery. Obtain initial access with the Hasson technique at the tip of the 12th rib. Then position a trocar-mounted balloon dissection device posterior to the kidney and inflate it. This device creates a working space to allow placement of the next trocar. Place the second trocar at the lateral border of the erector spinae muscle just below the 12th rib. Place the third trocar at the intersection of the anterior axillary line and the downward sloping line made by the extension of the first two trocars.

PROCEDURE

Laparoscopic Tumor Exposure

If transperitoneal access has been gained, take a brief survey of the intraperitoneal organs. Inspect the bowel for injury, and look at the liver for evidence of mass lesions. Reflect the colon with gentle medial traction provided by an atraumatic laparoscopic grasper. Incise the thin layer of mesentery lateral to the edge of colon but medial to the actual line of Toldt to expose the bloodless plane between the mesentery and Gerota’s fascia. We prefer the Harmonic Scalpel (Ethicon Endo-Surgery, Cincinnati, OH) for dissection. On the right, expose the duode-

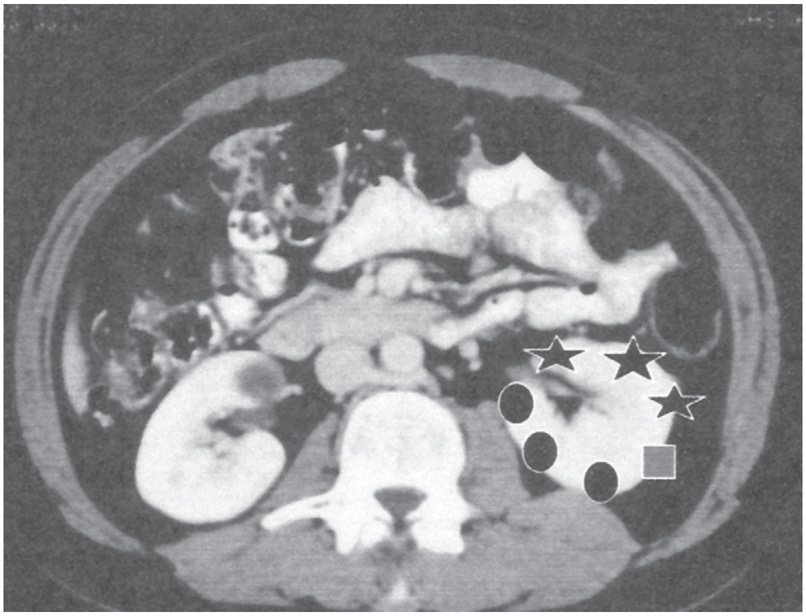

FIGURE 13–3. Anterior tumors (*stars*) are usually best approached by a transperitoneal approach. Tumors (*circles*) are usually best approached with a retroperitoneal approach. The tumor indicated by a *square* is in a location that can be treated with either approach.

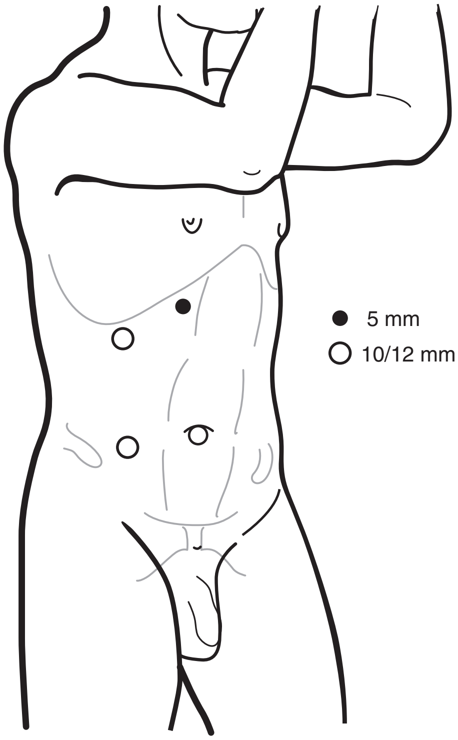

FIGURE 13–4. Transperitoneal trocar positions.

num and kocherize. These steps provide visualization of the anterior surface of Gerota's fascia overlying the kidney and anterior hilum. For the retroperitoneal approach, the psoas muscle and the pulsations of the renal artery are usually immediately visible and serve as important anatomic landmarks.

Regardless of approach, enter Gerota's fascia near the tumor. If the patient has significant perirenal fat and the tumor is difficult to discern, laparoscopic US with a flexible probe helps expedite tumor identification. Excise the fat overlying the tumor, and send it for histopathologic examination. Extensively mobilize the kidney within Gerota's fascia. Renal mobilization allows for passage of a flexible laparoscopic US probe on the surface of the kidney opposite the tumor to optimize imaging and targeting of the tumor. Note the tumor size, margins, vascularity, and proximity to collecting system or hilar structures. Next, percutaneously pass a biopsy device with a 15-gauge Tru-Cut needle (ASAP Biopsy System, Microvasive; Boston Scientific, Watertown, MA) into the tumor and tissue obtain a sample for histopathology.

Laparoscopic Cryoablation

Percutaneously introduce the probes and visually guide them into the tumor. Because the temperature extremes are realized only at the distal aspect of the probes for CA and RFA, skin complications are rare. Targeting tumors is the most challenging component of the procedure and will differentiate success from failure. Initially, collaborating with a radiologist familiar with US images of the kidney may help targeting. With experience, a radiologist is only infrequently required. On rare occasions, tumor identification is very challenging. In these cases, fill the operative field with sterile saline to help improve contact of the flexible laparoscopic probe with the kidney.

Tumor targeting and ablation are critical for success. Depending on tumor size, the number of cryoprobes can vary from one to four. We prefer 1.47-mm IceRods (Galil Medical, Plymouth Meeting, PA), which have been characterized to have an ablative diameter of 1.9 cm.[10] Typically, use a cluster of cryoprobes positioned 1.5 cm apart from one another in a triangular or quadratic configuration to ensure cryolesion overlap. Introduce the IceRods through an external template that is placed on the skin to ensure precise spacing. Mobilize the kidney so that the probes enter the renal parenchyma in a perpendicular manner whenever possible. Grasp the probes with a laparoscopic instrument and insert into the tumor such that they are parallel to each other, thus ensuring proper spacing. Position the flexible laparoscopic US probe to allow imaging of the deepest margin of the tumor. Introduce the IceRods into the tumor under US guidance, and advance them just beyond

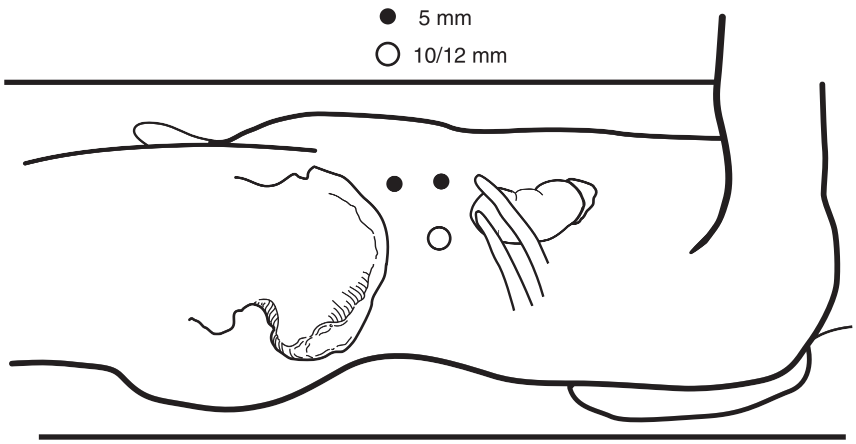

FIGURE 13–5. Retroperitoneal trocar positions.

the deepest margin. Next, perform a double freeze cycle each followed by an active thaw. Continue the first freeze until the iceball extends to a perimeter 1-cm margin beyond the tumor in every direction. Take care to prevent contact of the iceball with critical structures such as the renal vasculature, ureter, renal pelvis, and bowel structures. Mobilize and retract these structures, as needed, to prevent injury. After an appropriate margin has been achieved, perform an active thaw and deploy a second freeze cycle.

After the second freeze cycle, activate an active thaw and remove the IceRods only when they can be twisted gently without resistance. Exercise care not to apply premature force on the IceRods to avert potential fracture of the iceball from the kidney, which may be associated with significant hemorrhage. After removal of the IceRods, hemostasis is typically good and bleeding has not been a problem with these small-caliber probes. Usually, no hemostatic measures are required and we no longer use surgical hemostatics (e.g., fibrin glues or FloSeal). If bleeding does occur, apply gentle pressure for hemostasis.

Laparoscopic Radiofrequency Ablation

Achieve access as described for laparoscopic CA. Percutaneously introduce the probe and enter the tumor perpendicular to the surface of the kidney. Based on tumor size as measured by preoperative CT or MRI and intraoperative US imaging, deploy the tines to a diameter that ensures ablation of the tumor and a 1-cm margin of normal renal tissue. Multiple impedance-based or temperature-based probes are commercially available. Deploy the probes as per protocols, which are delineated in the manufacturer's recommendations. The size of the ablated area is dependent on the diameter of the deployed tines and the activation time. Typically, activation times range from 3 to 8 minutes, and two cycles are performed with a brief interval between cycles to allow cooling. After the tumor ablation is complete, ablate the probe tract while removing the probe from the kidney. This technique minimizes the risk of bleeding and tumor seeding.

Percutaneous Ablation

Administer a general anesthetic or conscious sedation, and position the patient prone in an interventional CT or MRI unit. MRI permits acquisition of sagittal or coronal T1 images to assist in spatial orientation. Position the tip of a 20-gauge needle just outside the tumor margin to define the eventual probe tract on repeat scans. Perform needle core biopsy of the renal mass along this tract. Advance the CA or RFA probe into the lesion as described for laparoscopic procedures. Obtain repeat scans before ablation to check probe position for adequacy. Perform ablation as described earlier. After ablation, use immediate CT with intravenous contrast to assess for enhancement. Alternatively, MRI demonstrates cryolesions as a signal void on T1-weighted images. Pass absorbable hemostatic material through an introducer after removing the probe to assist hemostasis.[11]

POSTOPERATIVE MANAGEMENT

Patients are quickly advanced to a regular diet as tolerated. A hematocrit is checked in the recovery room and the morning after surgery. Percutaneously administered treatment may permit outpatient care; otherwise, patients are discharged in 23 hours. As per our protocols, patients have follow-up evaluations 1, 3, and 6 months after the procedure with contrast CT or MRI. Then, CT or MRI is obtained every 6 months until 3 years after surgery and then annually. Complete loss of contrast enhancement on follow-up CT or MRI is considered a sign of complete tissue destruction.[4,11] Indeed, we have found that the 3-month imaging follow-up evaluation is the most accurate to determine the success of ablation. Although each urologist must develop a postoperative follow-up plan, initial postoperative imaging at 3 months is suggested at this time.

COMPLICATIONS

Table 13–1 summarizes the complications of CA and RFA reported in the literature. The meta-analysis shows similar complication rates of 10.6% for CA and 13.9% for RFA. In a recent multi-institutional review of CA and RFA procedures, a comparable overall complication rate of 11.1% was reported (14.4% after CA and 7.6% after RFA).[26] The same authors reported similar complication rates between procedures performed laparoscopically (8.9%) and percutaneously (12.2%). The most common complication reported was pain or paresthesias related to the probe site, which was usually self-limited. When compared with LPN, the less technically challenging ablative procedures offer lower complication rates.

TABLE 13–1. COMPLICATIONS OF RENAL CRYOABLATION AND RADIOFREQUENCY ABLATION

Cryoablation				Radiofrequency Ablation			
Reference	Technique	No. of Patients	Morbidity	Reference	Technique	No. of Patients	Morbidity
Rodriguez et al[12]	Three laparoscopic/ four open	7	One pelvic thrombus One CVA	Matsumoto et al[18]	Laparoscopic	28	One UPJ obstruction Two minor
Harmon et al[13]	39 Laparascopic/37 open	76	Six capsular fractures Two prolonged ileus One CVA	DiMarco et al[19]	US/CT guided	66	One UPJ obstruction Two chronic lumbar pain One renal infarct One major hemorrhage
Nadler et al[14]	Laparoscopic	15	One respiratory failure One prolonged ileus	de Baere et al[20]	US/CT guided, 200 W	5	One subcapsular hematoma
Lee et al[15]	Laparoscopic	20	One pancreatic injury	Hwang et al[21]	Nine laparoscopic Eight US/CT guided, 200 W	17	One UPJ obstruction
Shingleton and Sewell[16]	MRI guided	90	One perinephric hematoma Eight minor	Roy-Choudhury et al[22]	US/CT guided, 200 W	8	Two renal infarcts One psoas thermal injury
Colon and Fuchs[17]	Laparoscopic	8	0	Mayo-Smith et al[23]	US/CT guided, 200 W	32	Two perinephric hematomas One probe site skin metastasis
				Su et al[24]	CT guided, 90 W	29	Eight hematomas One thermal hepatic injury One aspiration/death
				Ukimura et al[25]	US/CT guided, 100 W	9	One perinephric hematoma
Overall		216	23 (10.6%)	Overall		194	27 (13.9%)

CT, computed tomography; CVA, cerebrovascular accident; UPJ, ureteropelvic junction; US, ultrasonography.

SUMMARY

Cryoablation and radiofrequency ablation are new and promising technologies for the minimally invasive treatment of small renal cortical neoplasms. With 3- and 5-year follow-up data now demonstrating excellent efficacy, these technologies likely will be increasingly applied to treatment of the small renal mass. Certainly, 10-year follow-up data will help urologists establish the definitive role for these ablative technologies in clinical practice.

Tips and Tricks

- Tumor location within the kidney and relative to surrounding structures on preoperative imaging indicates whether a laparoscopic or percutaneous approach is prudent.
- Prone or lateral preoperative imaging for percutaneous procedures determines if intervening structures impede the tract of the ablation probe.
- High-quality recent (within 3 months) axial imaging (CT or MRI) helps facilitate tumor localization and targeting of ablation probes.
- Intraoperative real-time laparoscopic US is essential for tumor targeting and, during CA, for monitoring of iceball progression.
- Extensive mobilization of the kidney during laparoscopic procedures allows the flexible US probe to achieve multiple angles of vision of the tumor and ablation probes.
- During laparoscopic cases, flooding the operative field with sterile saline may help identify very challenging tumors by improving flexible laparoscopic ultrasound probe contact with the kidney.
- Both CA and RFA are viable options for the treatment of small renal tumors, less challenging than LPN, and associated with lower complication rates.

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CHAPTER 14

Laparoscopic Renal Biopsy

Stephen V. Jackman

Renal biopsy is a crucial tool in the diagnosis of medical disease of the kidney. Histologic information is pivotal in making treatment decisions and providing prognostic information. Ultrasound (US)-guided percutaneous needle biopsy is the current standard for obtaining renal tissue. It has the advantage of being performed under local anesthesia in an outpatient setting. Unfortunately, there is up to a 5% rate of significant hemorrhagic complications.[1]

In instances in which percutaneous biopsy has failed or is considered to pose a high risk, patients are traditionally referred for open renal biopsy. This procedure allows the advantage of obtaining hemostasis and plentiful cortical tissue under direct vision. However, open renal biopsy has the associated morbidity of an incision and general anesthesia. Laparoscopic renal biopsy combines the advantages of open biopsy with the decreased morbidity of a two-port outpatient procedure. General anesthesia is still required.

INDICATIONS AND CONTRAINDICATIONS

The indication for renal biopsy is suspected renal disease, the treatment of which would be influenced by the results of histopathologic tissue analysis. The indications for directly visualized renal biopsy include three categories: failed percutaneous needle biopsy, difficult anatomy, and high risk for bleeding complications.

Anatomic factors that may make a patient unsuitable for percutaneous biopsy include morbid obesity, multiple bilateral cysts, a body habitus that makes positioning impossible, and a solitary functioning kidney. The risk of hemorrhagic complication may outweigh the advantages of percutaneous biopsy in patients who are receiving long-term anticoagulation, have coexistent coagulopathy, or refuse blood transfusion under any circumstance. Laparoscopic renal biopsy is contraindicated in patients with uncorrected coagulopathy, uncontrolled hypertension, or inability to tolerate general anesthesia.

PATIENT PREOPERATIVE EVALUATION AND PREPARATION

Patients undergo routine screening history, physical examination, and blood analyses, including a complete blood count, basic metabolic panel, coagulation panel (prothrombin time, activated partial thromboplastin time), and blood typing with antibody screening. Any problems are evaluated and corrected to the extent possible as determined by the urgency of the biopsy. Additionally, patients must be told to refrain from taking aspirin, nonsteroidal anti-inflammatory drugs (except selective cyclooxygenase-2 inhibitors) and clopidogrel [Plavix]) for 5 to 10 days before their procedure. Patients with bleeding disorders need 2 to 4 units of packed red blood cells cross-matched and available before the start of the procedure.

The patient on long-term anticoagulation therapy is managed in cooperation with the primary physician, nephrologist, or cardiologist. Ideally, if the patient can tolerate cessation of anticoagulation for a short time, the patient stops warfarin 4 to 5 days before admission and undergoes a prothrombin time check the day before surgery. Fresh-frozen plasma can be given if needed just before the procedure. The patient who cannot tolerate cessation of anticoagulation also stops taking warfarin 4 to 5 days before the procedure but must be admitted 2 days before surgery for intravenous anticoagulation. This therapy can be discontinued 6 hours before incision. Alternatively, the patient may be managed as an outpatient with low-molecular-weight heparin injections.

Ideally, the patient can resume the usual oral warfarin dose 24 to 48 hours after surgery, but this must be done cautiously. Closely follow up with patients who require intravenous heparin to ensure that they do not become supratherapeutic.

Patients with thrombocytopenia, which is common in several renal diseases, can receive platelets 30 minutes before incision to boost their platelet count to greater than 50,000 cells/mm^3. Further platelet transfusion is not necessary in the absence of symptomatic bleeding. Uremic patients may benefit from desmopressin acetate (DDAVP) treatment to improve platelet function.

OPERATING ROOM CONFIGURATION AND PATIENT POSITIONING

The surgeon and assistant both stand at the patient's back. Place the video monitor in front of the patient. Position the scrub nurse or technician in front of the patient, caudad to the monitor (Fig. 14–1). In addition to standard laparoscopic equipment, required tools include an optical trocar (Visiport [U.S. Surgical, Norwalk, CT]; Optiview [Ethicon Endo-Surgery, Cincinnati, OH]; or Optical Separator [Applied Medical, Rancho Santa Margarita, CA]), 5-mm two-tooth laparoscopic biopsy forceps, argon beam coagulator, and oxidized regenerated cellulose (Surgicel [Johnson & Johnson, Arlington, TX]).

Place the patient on the operating table in the supine position, then apply antiembolism stockings and sequential com-

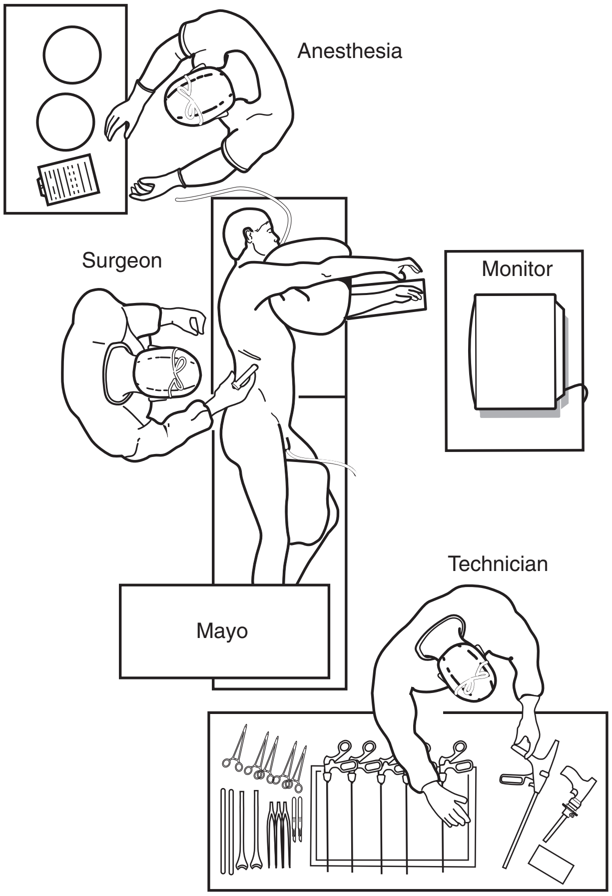


FIGURE 14–1. The surgeon stands behind the patient and a single video monitor is placed in front of the patient. The scrub nurse or technician is located in front of the patient caudad to the monitor.

pression devices. Induce general endotracheal anesthesia, then place an orogastric tube and a urethral catheter. Give from 1 to 2 g of cefazolin for antimicrobial prophylaxis.

Primarily base the choice of which kidney to biopsy for a sample on patient-specific anatomic considerations. A right-sided procedure may be more comfortable for right-handed surgeons, whereas biopsy of the left kidney may involve better working angles due to its higher position. The technique is essentially the same regardless of side.

After inducing anesthesia, carefully roll the patient into the full flank position with the umbilicus over the table break. Fully flex the table to increase the space between the iliac crest and the costal margin. Additionally, raise the kidney rest as needed. Carefully support the head with the headrest, folded sheets, and a head support ring. Align the cervical spine with the thoracic and lumbar spine. Place an axillary roll just below the axilla, and gently extend the arms. Pad the lower elbow with egg crate foam, and place several pillows between the arms.

Securely tape the upper body and arms to the table in position using 3-inch cloth adhesive tape. Use a towel or egg crate foam to protect the skin, upper elbow, and nipples from direct contact with the tape. Some skin contact is often necessary to adequately stabilize the patient.

Flex the lower leg at the hip and knee and pad under the ankle. Leave the upper leg straight and separate it from the lower leg with one or two pillows. Place a standard safety strap around the legs and table at the level of the knees. Securely tape the pelvis in position with more cloth tape, using a towel or egg crate foam over the genitalia for protection. Place grounding pads for electrocautery and the argon beam coagulator on the exposed upper thigh. Then shave, prepare, and drape the patient in standard surgical fashion (Figs. 14–2 and 14–3).

TROCAR PLACEMENT

Retroperitoneal access is identical for either right- or left-sided procedures. Mark the skin midway between the iliac crest and the tip of the 12th rib roughly in the posterior axillary line (Fig. 14–4). Make a 10-mm transverse incision in the skin, and use a small curved hemostat to spread the skin and subcutaneous fat. Place a 0-degree lens with the light on “standby” and focused on the blade of an optical trocar in the incision. Holding the optical trocar perpendicular to the skin and aiming approximately 10 degrees anteriorly, repeatedly fire the blade under direct vision until the retroperitoneum is entered. This requires traversing subcutaneous fat and either the lumbodorsal fascia or the flank musculature (external and internal obliques and the transversus abdominis) (Fig. 14–5). Straying too far anteriorly can result in peritoneal entry or colon injury, whereas posteriorly, the quadratus or psoas muscles can be damaged, resulting in excessive bleeding.

Once the retroperitoneum is entered, remove the Visiport, leaving behind the 12-mm port. Begin CO_2 insufflation at a pressure of 15 to 20 mm Hg. Use blunt dissection with the laparoscope to develop the retroperitoneal space. Anteriorly, sweep the peritoneum medially with the laparoscope, exposing the underside of the transversalis fascia (Fig. 14–6). Once anterior dissection has mobilized the peritoneum medial to the anterior axillary line, place a 5-mm port under direct vision at the same level as the first port (Fig. 14–7). Then use laparoscopic scissors with electrocautery or a Harmonic Scalpel (Ethicon Endo-Surgery, Cincinnati, OH) to assist in completion of retroperitoneal space development. The superior extent of dissection is Gerota’s fascia at the level of the lower pole of the kidney.

Open, Hasson-type, entry into the retroperitoneum and balloon dissection is an alternative to the method just described (see Chapter 1, Basic Techniques in Laparoscopic Surgery). The balloon is best placed inside Gerota’s fascia before inflation, if possible, for the most efficient access to the kidney.

PROCEDURE

Kidney Exposure and Biopsy

Once both the camera and working trocar are in position and an adequate working space has been created, direct the instruments away from the midline toward the lower pole of the kidney (Fig. 14–8). Locate the kidney by palpation and sharp dissection through Gerota’s fascia. The change to a darker-yellow fat upon entry into Gerota’s fascia helps identify the kidney (Fig. 14–9). In morbidly obese or other difficult situa-

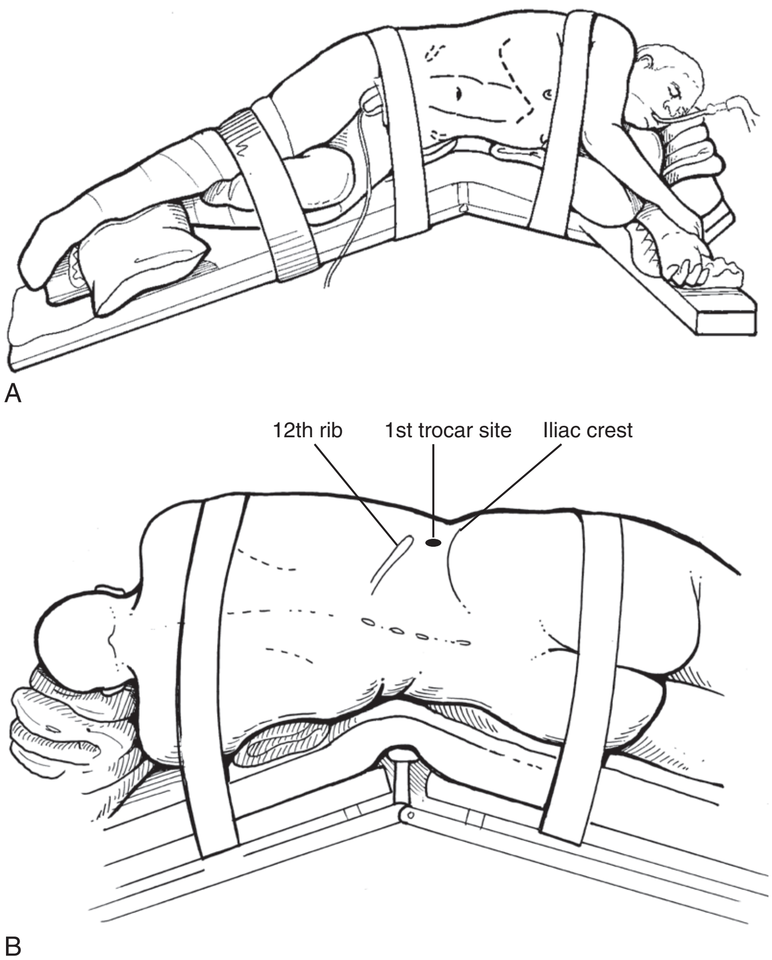


FIGURE 14–2. *A,* The patient is placed into a full flank position with the umbilicus over the table break. The table is fully flexed to increase the space between the iliac crest and the costal margin. Additionally, the kidney rest may be raised as needed. The head is carefully supported with the headrest, folded sheets, and a head support ring. The lower elbow should be padded with egg crate foam, and several pillows are placed between the arms. The chest, pelvis, thigh, lower leg, and arms are securely taped with 3-inch cloth adhesive tape. *B,* The cervical spine should be aligned with the thoracic and lumbar spine. An axillary roll is placed just below the axilla, and the arms are gently extended.

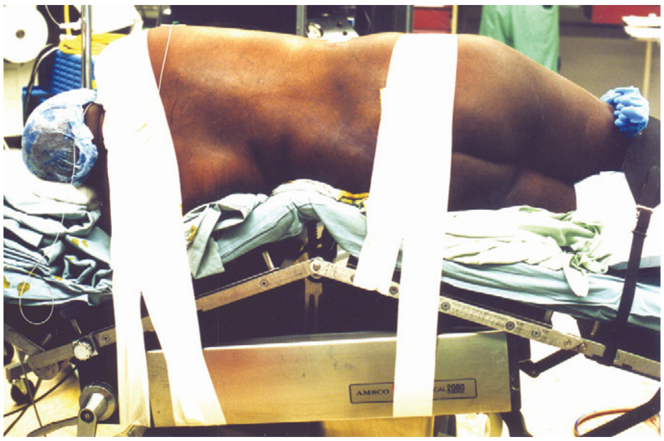


FIGURE 14–3. Patient positioned for laparoscopic renal biopsy.

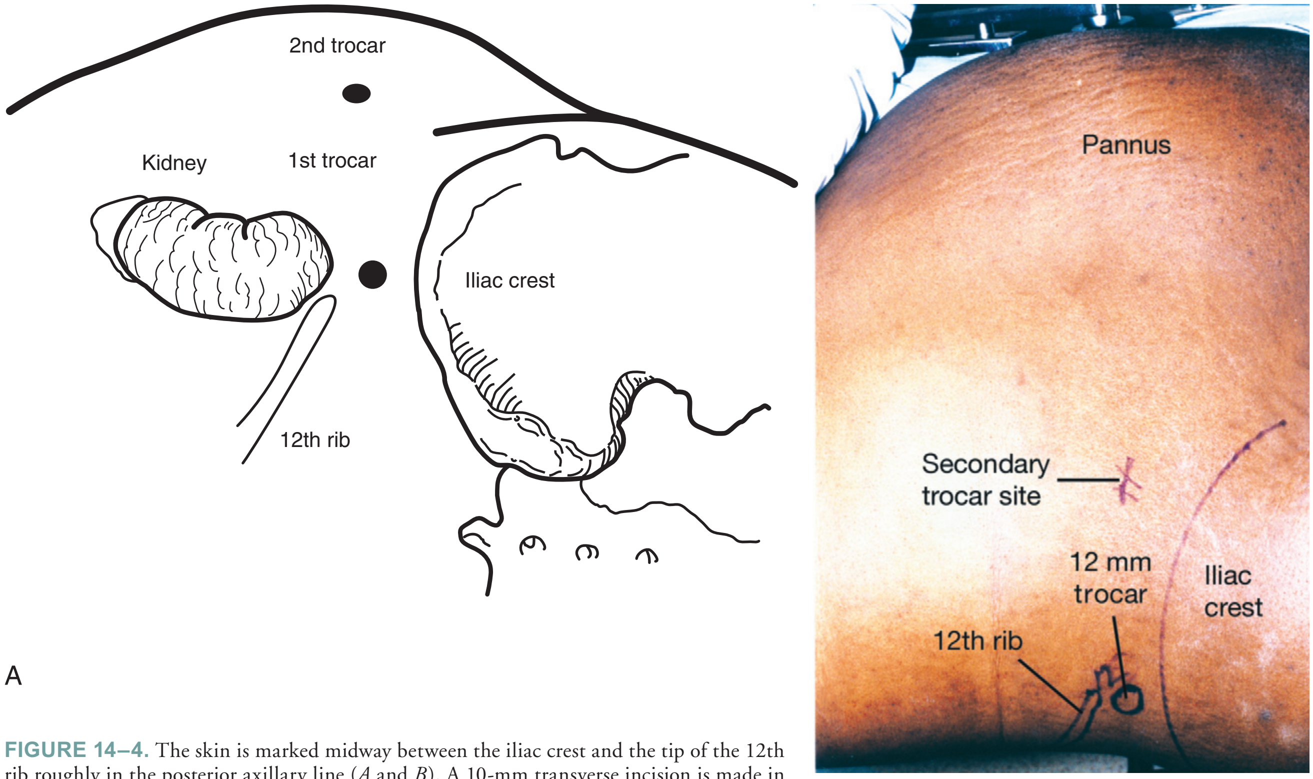
tions, preoperative transcutaneous or intraoperative US may be valuable in localizing the kidney.

Once Gerota's fascia is incised, sweep the perirenal fat aside to expose an approximately 2 × 2 cm area of the lower pole (Fig. 14–10). Use the 5-mm two-tooth biopsy forceps to take two or three good cortical renal biopsy specimens (Fig. 14–11). Place these in saline and transport them immediately to pathology for confirmation that adequate kidney tissue was obtained. Do not place the specimens in formalin; important information will be lost if the specimens are placed in formalin before processing. Frozen section or gross inspection under a dissecting microscope will confirm the presence of renal tissue. The pathologist can then place the tissue in the appropriate fixative for analysis.

Hemostasis and Closure

Obtain hemostasis with the argon beam coagulator. During activation of the argon beam, it is important to vent the increased pressure created in the retroperitoneum by the flow of argon gas (Fig. 14–12). While awaiting pathologic confirmation of sufficient specimen, lower the insufflation pressure to 5 mm Hg for at least 5 minutes and inspect the entire retroperitoneum for hemostasis. Treat persistent bleeding from the biopsy site with repeated argon beam coagulation. Pack oxidized cellulose (Surgicel) into the biopsy site and apply direct pressure (Fig. 14–13). Other adjuncts to hemostasis are needed rarely; these include various fibrin glues, matrix hemostatic sealant (FloSeal, Baxter, Fremont, CA), and surgical adhesives (BioGlue, CryoLife, Kennesaw, GA). Clip oozing vessels that are distant from the biopsy site with a 5-mm clip applier instead

Text continued on page 169



B

FIGURE 14–4. The skin is marked midway between the iliac crest and the tip of the 12th rib roughly in the posterior axillary line (*A* and *B*). A 10-mm transverse incision is made in the skin and a small curved hemostat is used to spread the skin and subcutaneous fat.

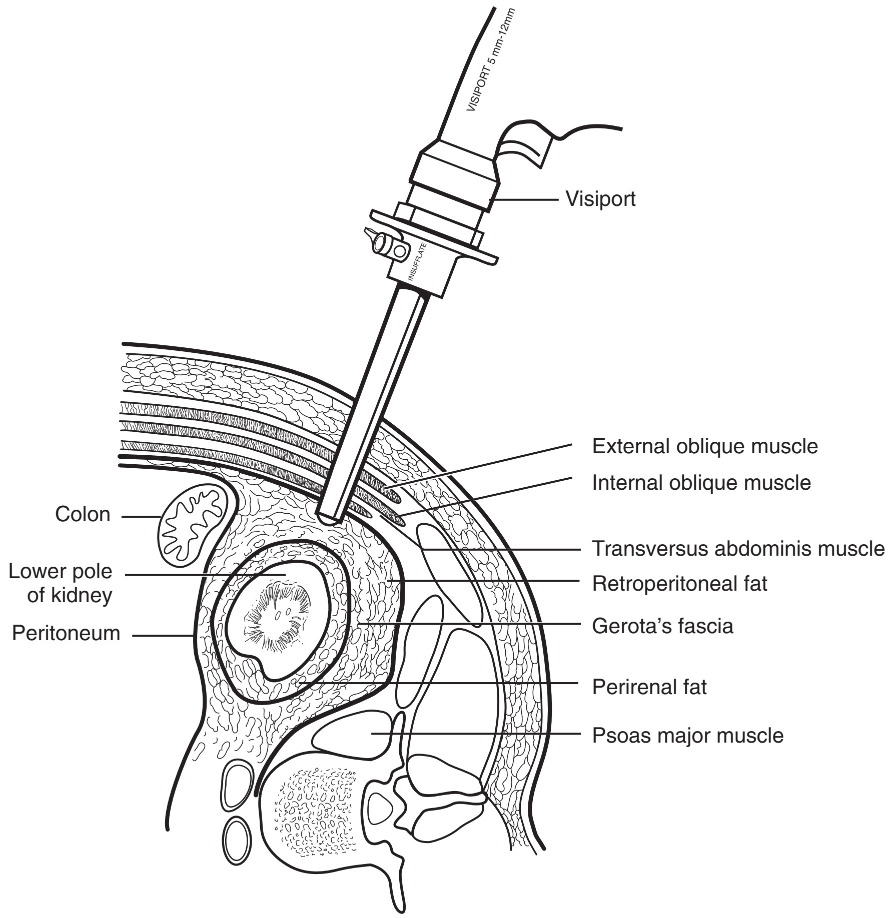


FIGURE 14–5. Use of an optical trocar such as the Visiport (U.S. Surgical, Norwalk, CT) allows the trocar to be advanced through the fascial layers into the retroperitoneum under direct vision.

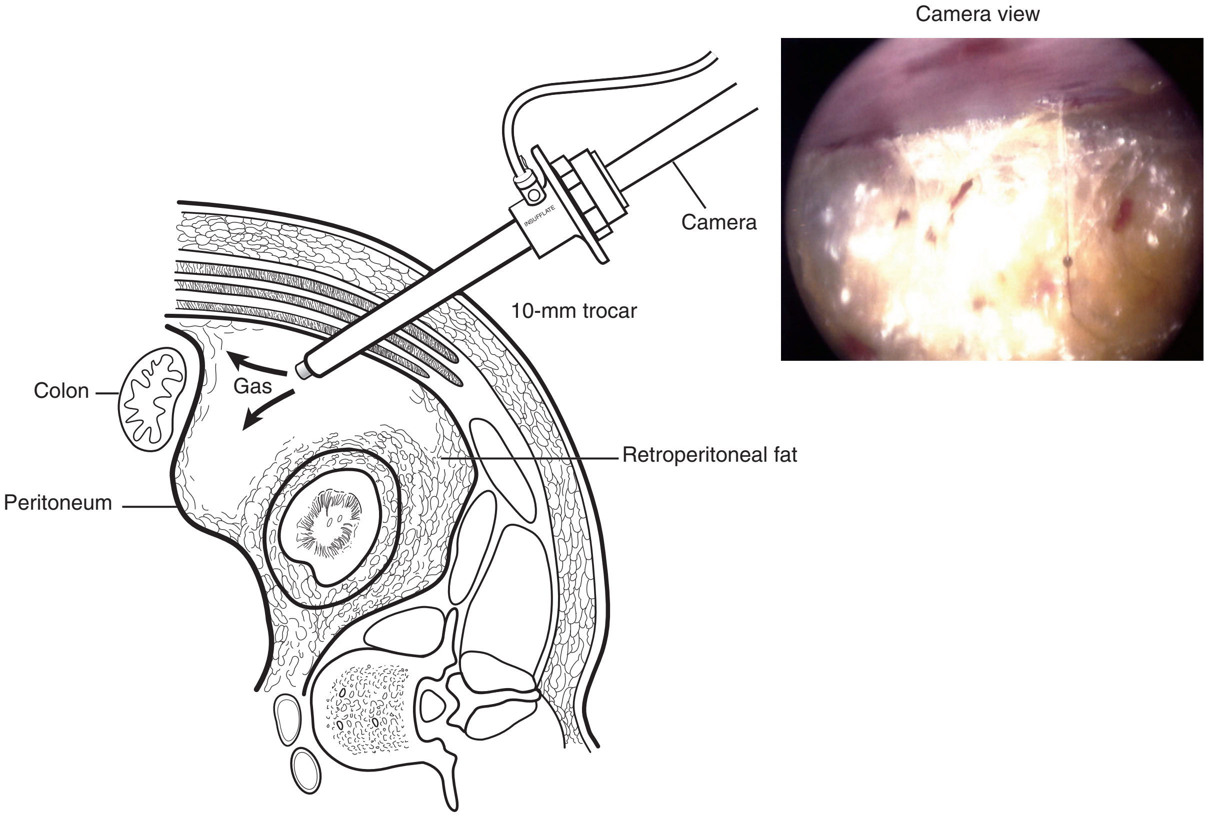


FIGURE 14–6. The visual obturator of the optical trocar is removed and the 0-degree laparoscope is used to bluntly push the peritoneum medially, creating a working space large enough to allow placement of the second trocar. Insufflation will help maintain the space as it is created. During this dissection, the laparoscope is directed medially, toward the peritoneum and abdomen.

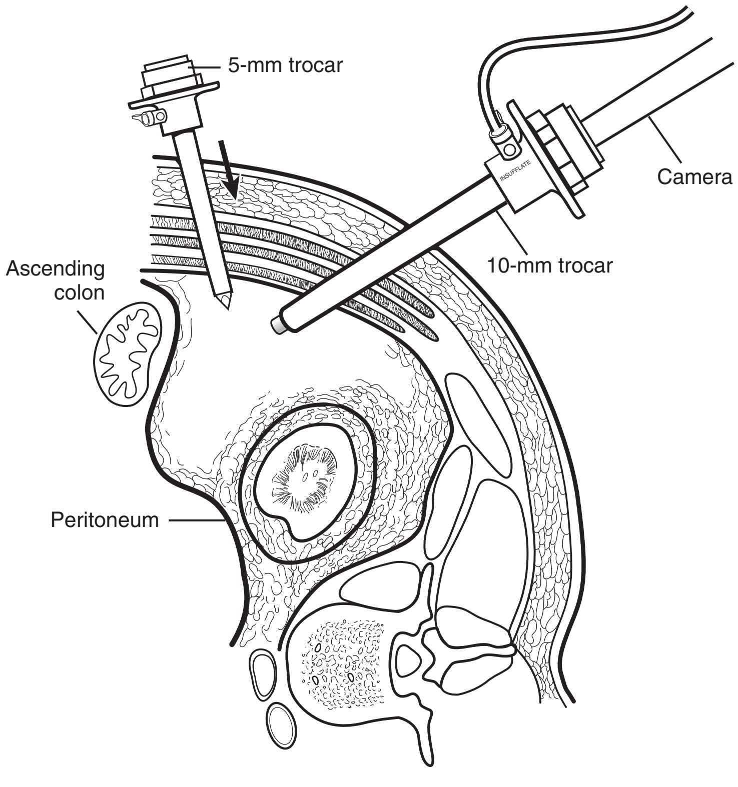


FIGURE 14–7. A 5-mm trocar is placed under direct vision. The working instruments are passed through this port. The camera can be used to assist with further dissection and is frequently cleaned to maintain visualization.

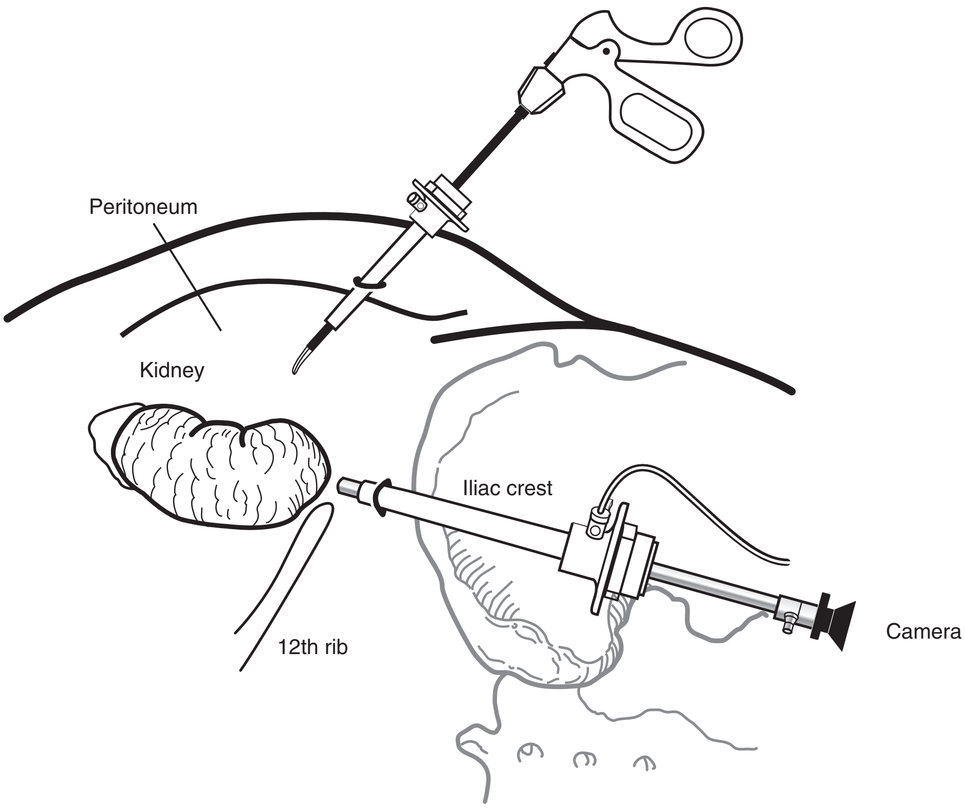


FIGURE 14–8. Once both trocars are in position, the camera and scissors are turned away from the midline and directed toward the lower pole of the kidney.

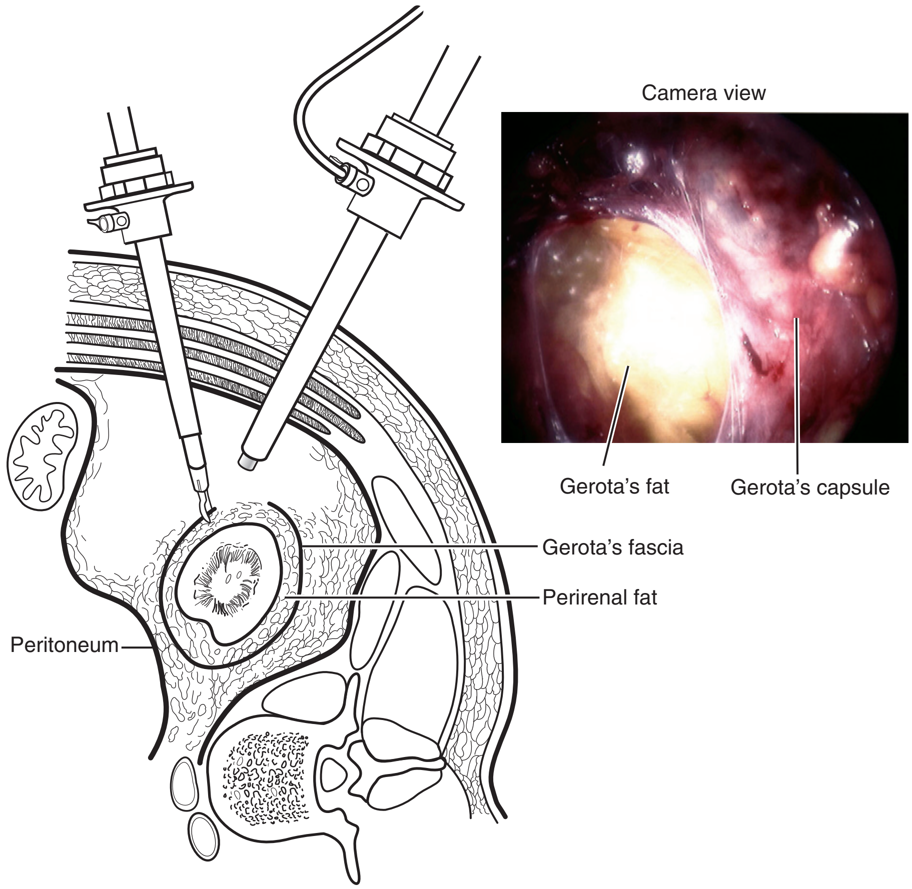


FIGURE 14–9. Gerota's fascia is opened with the scissors. The change to a darker-yellow fat on entry into Gerota's fascia is helpful in positively identifying the perirenal fat. Placing the camera and instrument in the opening and moving them in opposite directions will enlarge the window.

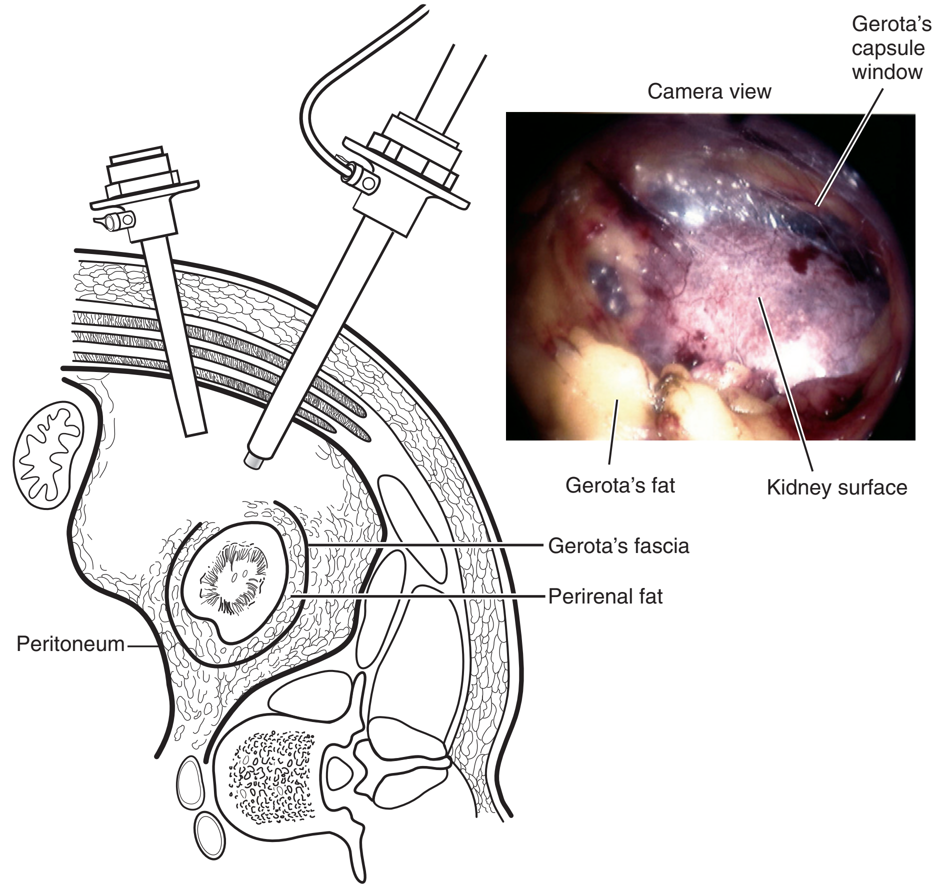


FIGURE 14–10. The perirenal fat is swept aside to expose the renal parenchyma.

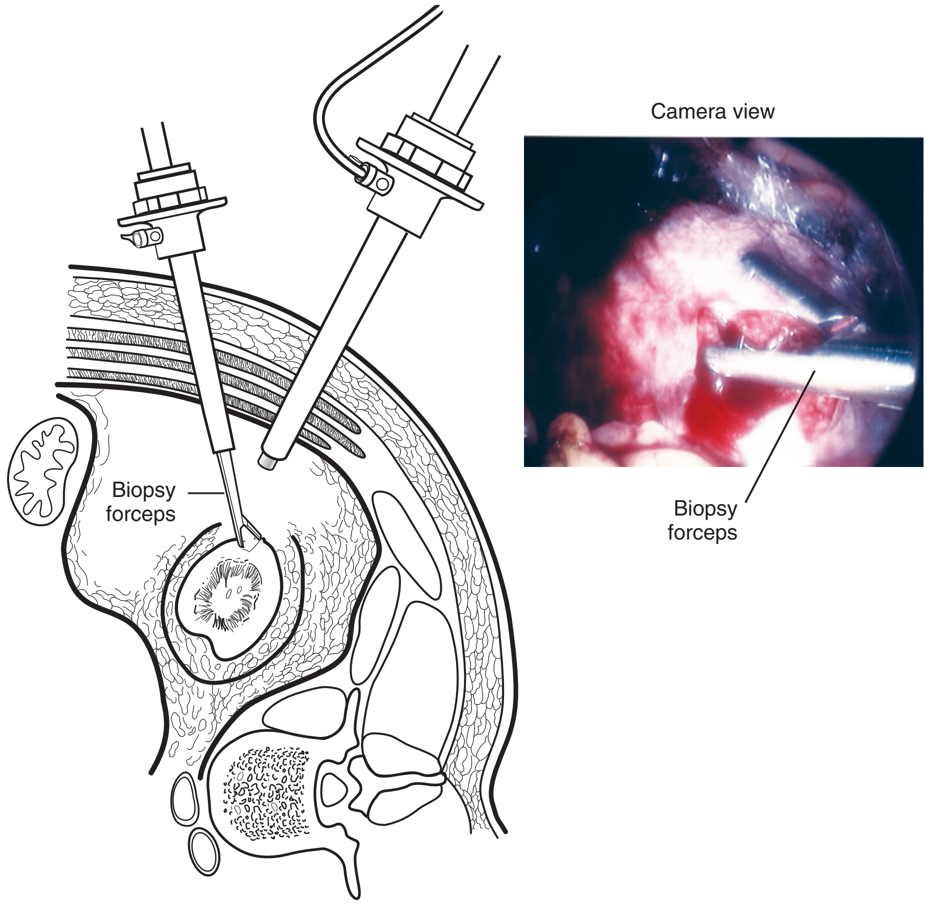


FIGURE 14–11. A 5-mm two-tooth biopsy forceps is used to take two or three samples from the lower pole of the kidney.

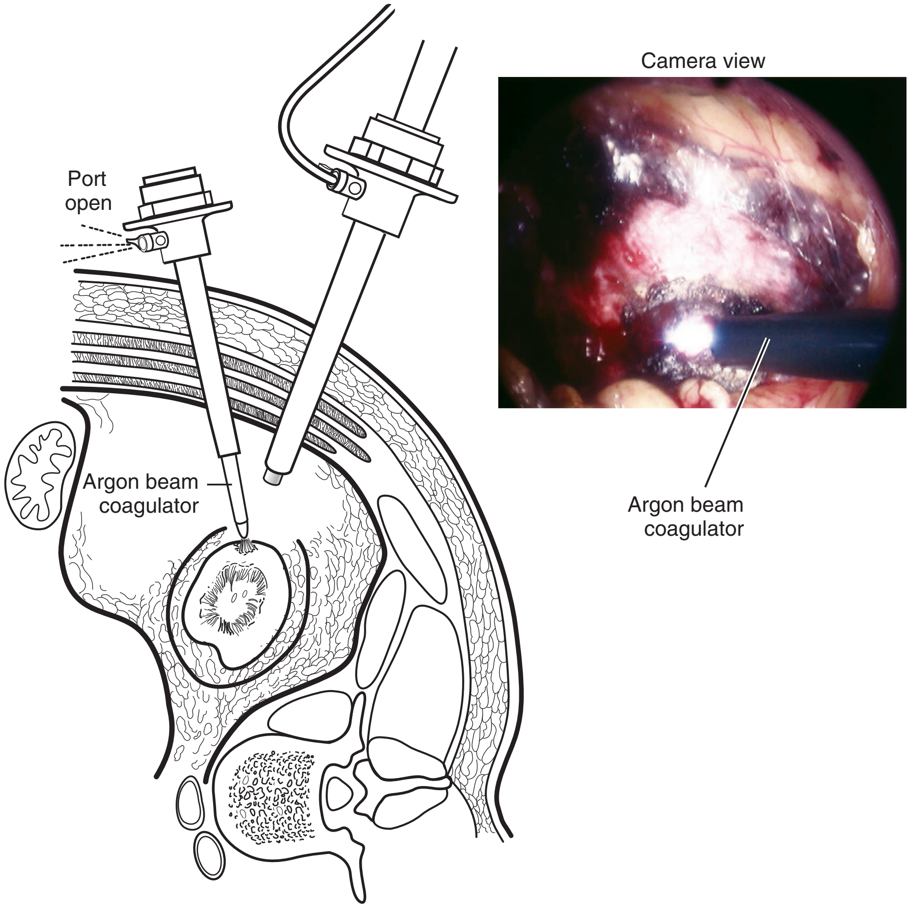


FIGURE 14–12. The argon beam coagulator is used to obtain hemostasis. The pneumoperitoneum pressure is lowered to 5 mm Hg, and the site of the biopsy is observed for active bleeding, which is re-treated with argon beam coagulation.

of electrocautery or argon beam; these may cause a thermal injury to bowel on the other side of the peritoneum.

After confirming hemostasis under low pressure, discontinue insufflation and remove the 5-mm port under direct vision. Evacuate the gas via the 12-mm port with the assistance of manual flank compression and large-volume breaths given by the anesthesiologist. If the peritoneum has not been perforated, the fascial layers do not require suture closure. Irrigate the skin incisions, inspect them for hemostasis, and close them with a 4-0 absorbable subcuticular suture. Apply tincture of benzoin and sterile skin closure tapes.

POSTOPERATIVE MANAGEMENT

Routine postoperative monitoring is performed based on the patient's health status. Specific attention is given to blood pressure control. Most nonhospitalized patients (i.e., those undergoing biopsy as an outpatient procedure) can be discharged the same day or the next morning. They are given oxycodone with acetaminophen for pain control and are instructed to avoid vigorous activity for 6 to 8 weeks.

COMPLICATIONS

Hemorrhage is the most common major complication. Careful resumption of anticoagulation is mandatory, as discussed. Evaluate a persistent decline in hematocrit or symptoms of hypovolemia using computed tomography (CT) scan. Colon injury may manifest as fever, ileus, or leukocytosis. Laparoscopic bowel injuries may present atypically as only port-site pain and vague constitutional symptoms. Again, CT scan is the initial diagnostic modality of choice.

A review of 74 consecutive patients who underwent laparoscopic renal biopsy reported 96% success in obtaining adequate tissue for histopathologic diagnosis.[2] Mean blood loss was 67 mL, and operative time was 2 hours. Surgical complications included one inadvertent biopsy each of the spleen and liver without consequence, one seromuscular colonic injury, one postoperative hematoma, and two intraoperative bleeds. One patient on high-dose steroids died secondary to a perforated peptic ulcer 7 days after surgery. Forty-three patients (58%) were discharged within 24 hours.

SUMMARY

Laparoscopic renal biopsy is a less invasive alternative to open renal biopsy in centers where the proper equipment and expertise are available. Many patients can be treated in an outpatient setting. Adequate tissue, rich in glomeruli, is obtained from the cortex of the kidney, and hemostasis is obtained under direct vision before closure.

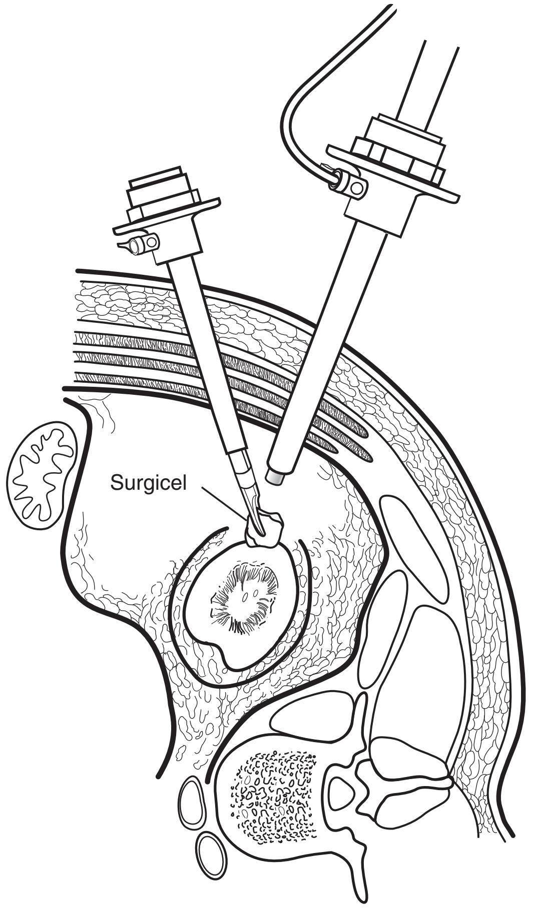


FIGURE 14–13. Surgicel is passed down the 5-mm port and placed over the area of the biopsy.

Tips and Tricks

- Intraoperative US can be helpful both before and during the procedure to locate the lower pole of the kidney in obese patients.
- The change to a darker-yellow fat color is indicative of entry into Gerota's fascia.
- Careful attention to postoperative blood pressure management and anticoagulation is key to the prevention of complications.

REFERENCES

1. Wickre CG, Golper TA: Complications of percutaneous needle biopsy of the kidney. Am J Nephrol 2:173, 1982.
2. Shetye KR, Kavoussi, Ramakumar S, et al: Laparoscopic renal biopsy: A 9-year experience. BJU Int 91:817-820, 2003.

CHAPTER 15

Laparoscopic Pyeloplasty

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Sam B. Bhayani

Laparoscopic pyeloplasty has evolved into a new standard of care for the treatment of ureteropelvic junction obstruction. Since it was introduced in the early 1990s,[1,2] the laparoscopic approach has maintained the high efficacy of open surgery without the coincident morbidity of the open incision. Additionally, the approach is favored over endopyelotomy[3,4] because complex reconstruction can be performed, even in the presence of aberrant crossing vessels.[5] The surgery does require intracorporeal suturing skills, which may be perfected in an inanimate trainer before operative intervention.[6]

INDICATIONS AND CONTRAINDICATIONS

The indications for laparoscopic pyeloplasty include any patient who has documented ureteropelvic junction obstruction.[7] Preoperative three-dimensional computed tomography (CT) reconstruction of the ureteropelvic junction (UPJ) may allow visualization of crossing vessels,[8] but is not necessary in all cases. There are few contraindications to laparoscopic pyeloplasty. Besides routine surgical contraindications (medical comorbidities, multiple surgeries or infections, renal or ureteral adhesions, uncorrected coagulopathies), the operation may be performed in virtually any age patient and with any anatomic abnormality.[9] Crossing vessels, renal stones, and duplicated collecting systems can all be addressed laparoscopically. Laparoscopic pyeloplasty may also be performed after failed endopyelotomy, failed open pyeloplasty, or even failed laparoscopic pyeloplasty.[10,11]

PATIENT PREOPERATIVE EVALUATION AND PREPARATION

In assessing the degree of obstruction, a diuretic renal scan may help quantify blockage and residual function. An intravenous urogram or retrograde pyelogram may help define anatomic considerations before reconstruction. A CT angiogram or three-dimensional reconstruction of the UPJ may reveal anterior crossing arteries or veins that will require dismembered pyeloplasty and transposition of the vessels.[8,12] None of these studies, however, is absolutely compulsory because none of them is likely to change the need for surgical intervention. Nevertheless, the studies may produce a surgical map of the field, thus allowing for less intraoperative speculation.[12]

Obtain informed consent from the patient, and discuss major risks, benefits, and alternatives. Discuss general surgical risks and other risks more germane to the procedure, including the possibility of urine leak, injury to surrounding structures, failure of surgery, migration of stents and drains, open conversion, bleeding, loss of kidney function, and nephrectomy.

Patients may have existing indwelling stents from the diagnosis of obstruction and pain. Typically, indwelling stents may cause ureteral edema and thickening, and identification of the UPJ may be difficult. Consider removing the stent 1 week before surgery if the patient can tolerate this intervention.

Give the patient a bottle of magnesium citrate and clear liquids the day before surgery. This bowel preparation, although not completely necessary, allows decompression of the intestines and may help in visualization during dissection. A negative urine culture is needed or antibiotics are given at the time of surgery. After induction of general anesthesia, place an orogastric tube. Perform flexible or rigid cystoscopy and place a stent into the affected kidney. Use a long stent (7 Fr × 28 cm) so that it does not migrate out of the bladder during reconstruction. Perform a retrograde pyelogram if it is indicated. Place a urethral catheter, and reposition the patient for the pyeloplasty.

OPERATING ROOM CONFIGURATION AND PATIENT POSITIONING

The operating room is configured so that the surgeon and staff have excellent views of the laparoscopic surgical monitors (Fig. 15–1).

Positioning can be performed in a variety of methods. If a difficult dissection is anticipated, position the patient over the break in the table in case open conversion is needed. Place the patient into the full flank position (90 degrees) or the modified flank position (60 degrees, supported by a gel roll). Place the arms high so that they do not interfere with suturing (Fig. 15–2). No flexion is necessary in most cases. Consider adding an axillary roll and ensure adequate padding is used.

TROCAR PLACEMENT

Insert a Veress needle and establish a pneumoperitoneum. Place a 10/12-mm trocar at the umbilicus, a 5-mm trocar 6 to 8 cm superior to the umbilicus, and a 10/12-mm trocar 6 to 8 cm below the umbilical trocar. Place all trocars in the midline; this positioning facilitates ergonomic suturing (Fig. 15–3).

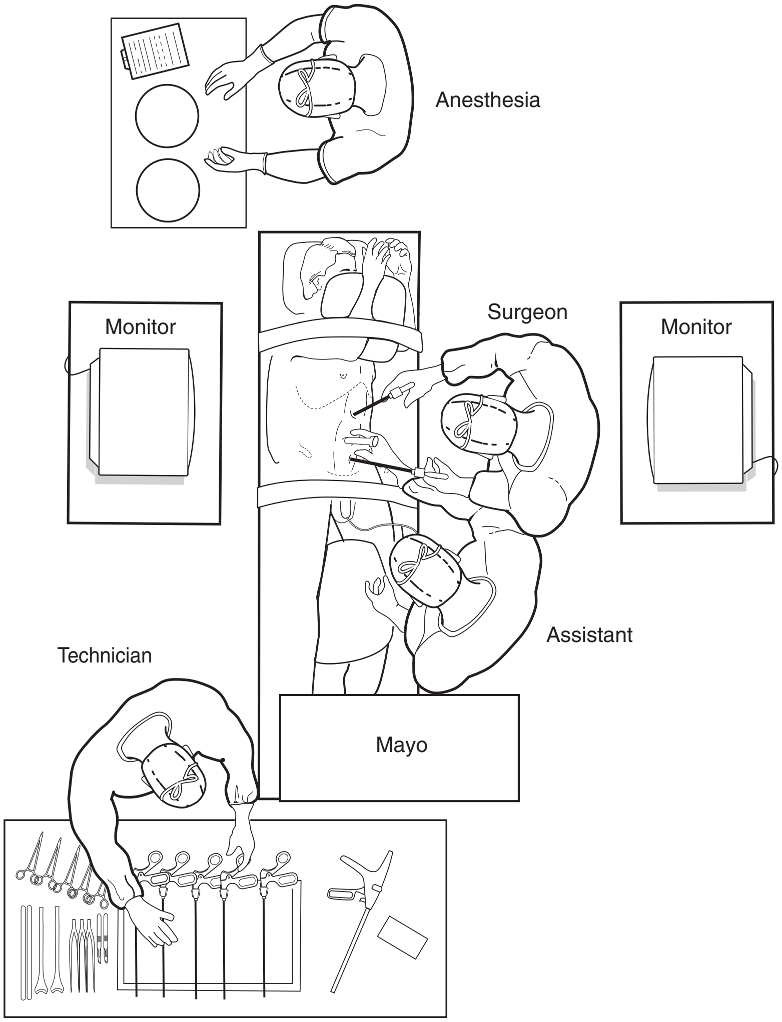

FIGURE 15–1. To allow visualization of the procedure by all members of the surgical team, the surgeon and assistant stand on the side contralateral to the pathology. The scrub nurse or technician stands on the opposite side to help with management of instrumentation.

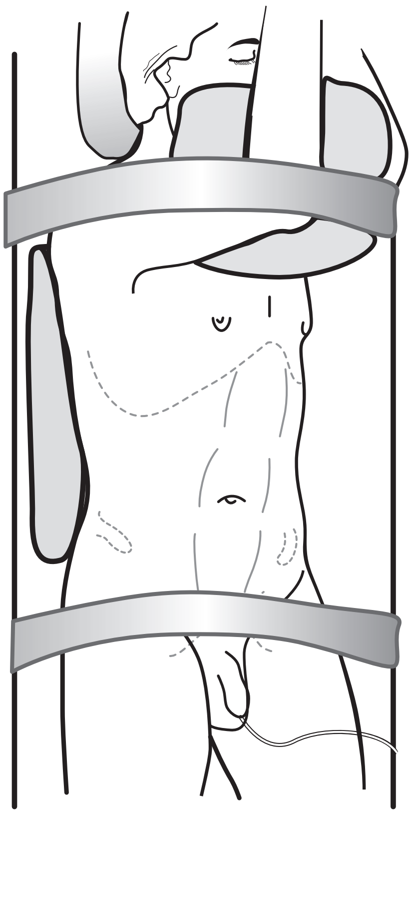

FIGURE 15–2. The umbilicus should be centered at the table break in the event that an open repair would be performed. An axillary role is placed under the lower arm, which is brought out perpendicular to the patient. The arms are then positioned in a "praying position" near the patient's head and separated by a small pillow. The contralateral lower knee is bent at a 90-degree position and the ipsilateral leg is kept straight with pillows or foam placed in between them. Wide cloth tape is placed across the upper shoulder/arm and hip and secured to the operative table.

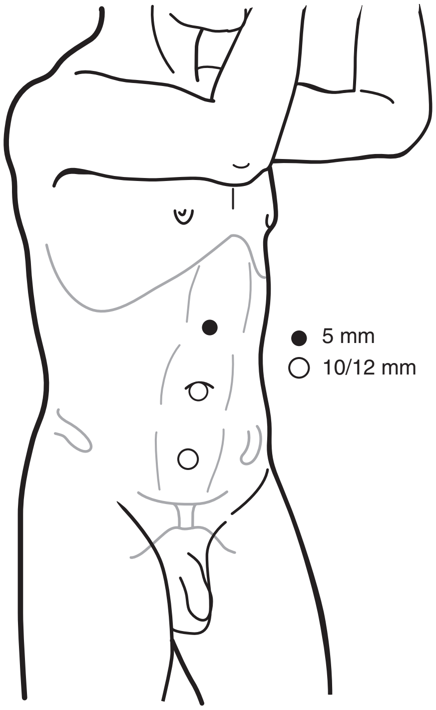

FIGURE 15–3. Trocar placement includes three midline trocars. A 10-mm trocar is placed at the umbilicus. The second port (5 mm) is placed midway between the xiphoid process and the umbilicus. A third trocar is located midway between the umbilicus and the symphysis pubis.

PROCEDURE

Use a 30-degree lens throughout the operation. Reflect the colon using standard laparoscopic techniques, similar to a radical nephrectomy, and identify the ureter. Take care not to mobilize the ureter aggressively because it is necessary to preserve the periureteric blood supply.

Expose the ureter only at the UPJ. The area can be easily found because the pelvis is typically hydronephrotic and the stented ureter can be felt with laparoscopic graspers. The gonadal vein may be mistaken for the ureter, and palpation of the structure may clarify the structure's identity. Take care in dissection of the UPJ because a crossing vessel may be present (Fig. 15–4). Once the UPJ is identified and crossing vessels are recognized, free the renal pelvis from its peripelvic attachments near the UPJ. This allows mobilization of the pelvis and proximal ureter for the anastamosis. Importantly, during the dissection of the UPJ, avoid clips because they could erode into the repair. Control bleeding with energy sources (ultrasonic shears, bipolar cautery, monopolar cautery, and so on), but avoid direct use of energy on the ureter. Control oozing at the cut edge with the sutures during repair.

Hynes-Anderson Dismembered Pyeloplasty

Once a crossing vessel is suspected during preoperative imaging or observed during the procedure itself, a Hynes-Anderson dismembered pyeloplasty is the treatment of choice.[5,13] This approach can also be used in virtually any UPJ obstruction.

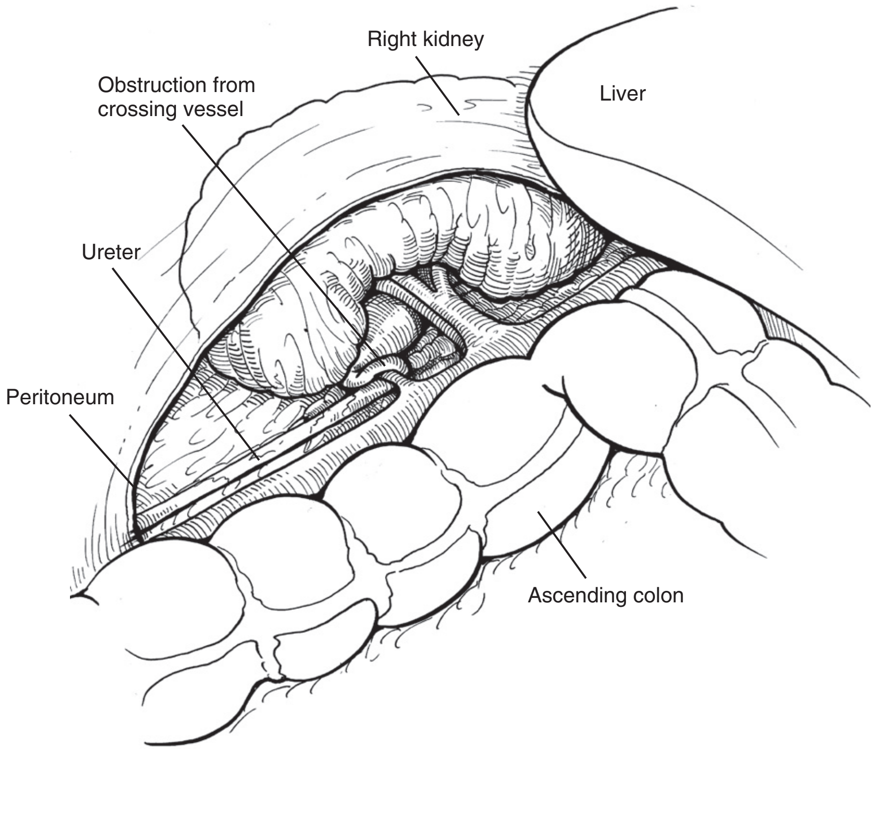

FIGURE 15–4. After the colon is reflected, the ureter is identified at the lower pole of the kidney. A crossing vessel is identified causing obstruction at the level of the ureteropelvic junction.

A segmental renal vessel can be identified in close proximity to the UPJ in up to 60% of patients, and its anterior position may be the cause of the obstruction. Perform the anastamosis between the ureter and the renal pelvis anterior to the vascular obstructing component.

When the renal pelvis is identified, mobilize it along with a small portion of the proximal ureter. Take care not to damage the small vessels supplying the pelvis because, theoretically, it may provide better viability of the anastomosis.

Make a circumferential incision over the renal pelvis above the anastomotic area (Fig. 15–5) and insert the stent. Complete the incision around the stent and along the renal pelvis wall. Take down redundant tissue to enable better approximation and technical results. Distally transect the UPJ using laparoscopic scissors and either remove the ring of ureteral obstructing tissue or incorporate it in the spatulation. Take care not to damage the ureteral stent during this manipulation. Make a 1-cm spatulation incision along the lateral or posterior wall of the proximal ureter. Spatulate the renal pelvis, if needed. Place a 4-0 polyglactin stitch at the tip of the spatulated ureter and then through the renal pelvis.

Once this knot is tied or secured with a Vicryl clip, use this stay suture to assist in applying interrupted sutures along the posterior pyelotomy, tying each knot outside of the urinary tract. These 4-0 sutures can also be placed with the EndoStitch laparoscopic suturing device (Auto Suture, Norwalk, CT)[14] (Figs. 15–6 and 15–7). Once the posterior wall is completed, insert the stent inside the renal pelvis and tailor the anterior portion of the renal pelvis to the spatulated ureter with interrupted 4-0 sutures.

Another method for the pyelotomy closure that is used today is a continuous closure using a double-armed, knotted suture.[15] Tie the sutures at their free end with a simple knot and drive each needle outside-in on the renal pelvis. One suture runs along the posterior wall continuously and the other runs over the anterior wall. Tie them together at the end, outside of the system, with a knot or a Lapra-Ty Vicryl clip (Ethicon Endo-surgery Inc, Cincinnati, OH)[14] (Fig. 15–8).

Foley Y-V Pyeloplasty

Use this approach in a small renal pelvis with a high inserted ureter and no crossing vessels. Make a wide-based V-shaped incision over the anterior aspect of the renal pelvis using the laparoscopic scissors (Fig. 15–9). Continue along with a vertical incision through the anterior proximal ureter, as low as 1 cm below the obstructed area. Using a 4-0 polyglactin suture, approximate the tip of the V shape to the apex of the proximal ureter incision. First, suture the medial arm of the V shape with interrupted 4-0 sutures using EndoStitch or standard knots, then insert the ureteral stent into the renal pelvis and close the anterior arm of the V shape with interrupted suturing.

Fenger Non-Dismembered Pyeloplasty

Use this approach with a small-sized renal pelvis and no crossing vessels. The procedure uses the Heineke-Mikulicz principle of a longitudinal incision closed in a transverse fashion. Compared to the procedures previously described, less suturing is needed, thus a shorter operative time is required. Make one long incision with laparoscopic scissors along the anterior renal pelvis and proximal ureter (Fig. 15–10), ending about 1 cm below the obstructed area. Place a 4-0 polyglactin suture from the superior apex of the incision on the renal pelvis, and approach to the inferior apex of the incision on the proximal ureter. Then use three to four interrupted sutures on each side for the transverse closure of the incision.

Take care not to damage the internal ureteral stent with the closure of the incision. With this approach there is no need to free the stent outside of the renal pelvis.

There is some debate as to whether or not this approach is as efficacious as a dismembered pyeloplasty.

Drain Placement

Leave a closed bulb suction drain in close proximity to the anastomotic area, preferably in a posterior position. A 7-Fr or 10-Fr Jackson-Pratt drain is commonly used.

Introduce the drain intra-abdominally through one of the laparoscopic ports (Fig. 15–11). Then make a new stab incision at the lateral abdominal wall and extract the drain outside the abdomen using a small hemostat. Alternatively, pass a drain with a sharpened spike into the retroperitoneum under direct vision, toward a trocar advanced deep into the abdomen, and toward the sharpened spike; pull the drain into the trocar with a spoon forceps. A retroperitoneal position for the drain is preferred because urinomas can drain posteriorly when the patient is recovering in the supine position. Use a nonabsorbable skin stitch to secure the drain.

POSTOPERATIVE MANAGEMENT

A 48-hour admission is typical. However, because urine leaks into the peritoneal cavity during the reconstruction, bowel may be irritated. As a result, the patient may have a slower return of normal bowel function and more postoperative pain compared with laparoscopic nephrectomy patients. Remove the orogastric tube at the end of the procedure. Give clear liquids the night of surgery and advance diet as tolerated.

Some give oral antibiotics throughout the stented period, but most give oral antibiotics only 2 to 3 days before stent removal. Take out the urethral catheter after 48 hours. It is mandatory to closely measure the drain output once the urinary catheter is removed. If this output does not increase in the 8 to 12 hours after catheter removal, remove the drain and discharge the patient.

Suspect anastomotic leak if an increased amount of urine (creatinine level at the drain fluid is higher than the plasma creatinine) is measured in the retroperitoneal drain after urinary catheter removal. Reinsert the catheter into the bladder until the drain output is no longer uriniferous. This may take up to 1 to 2 weeks. Consider the possibility of an obstructed or malpositioned stent if drain output is high with the catheter in place. A CT scan can help in assessment of stent positioning.

Leave the stent in place for 3 to 4 weeks. Consider a diuretic renal scan 6 weeks after surgery and every 4 to 6 months for 2 years. Failures usually occur within the first year postoperatively.[10,11]

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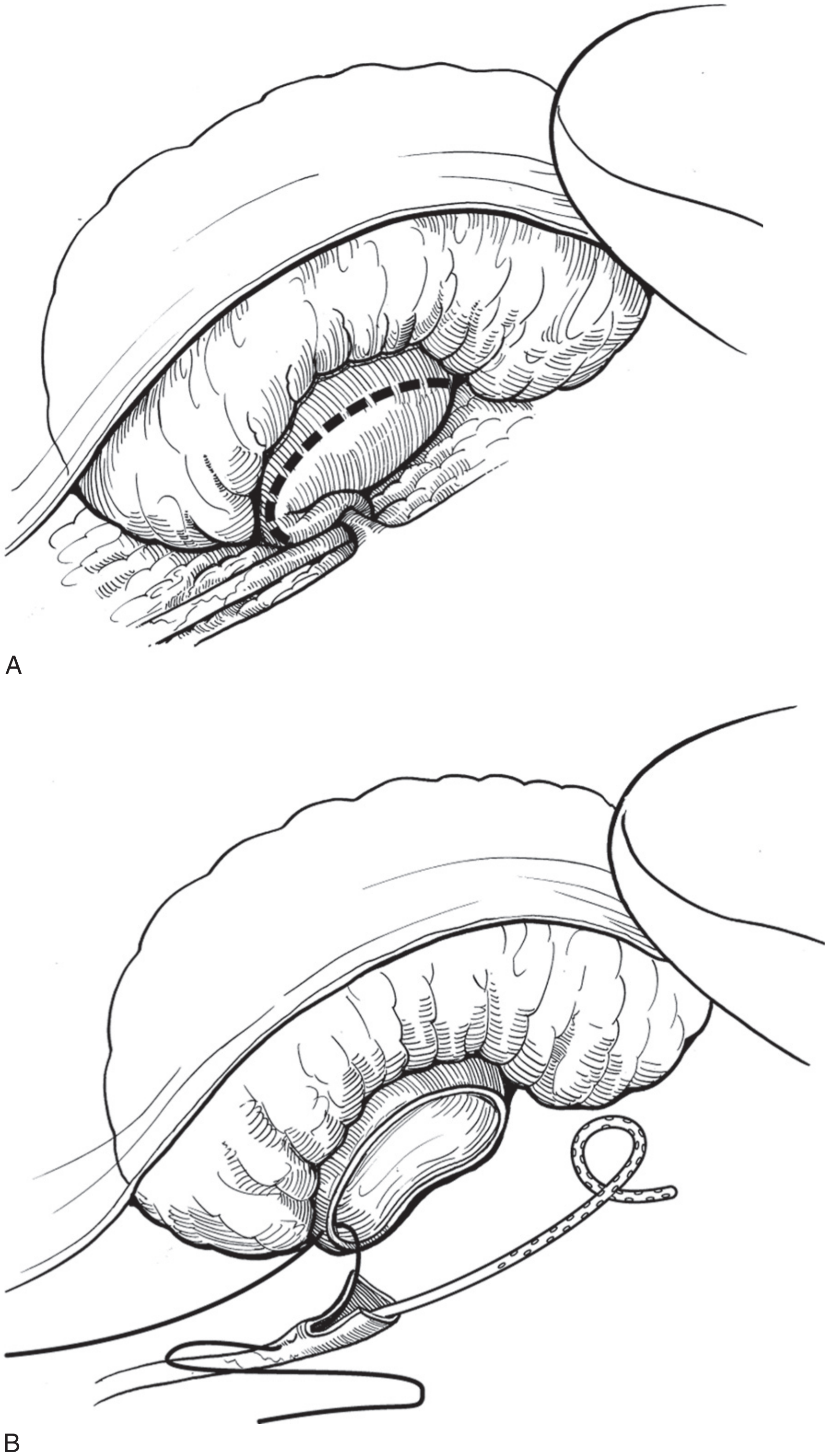

FIGURE 15–5. *A*, An incision is made on the dilated pelvis to transect the ureteropelvic junction. Care is taken to avoid cutting the stent. *B*, The ureter and pelvis are placed anterior to the crossing vessel. The redundant pelvis and stenotic ureteropelvic junction have been excised and the proximal ureter spatulated. The first suture has been placed from the apex of the spatulated ureter to the most dependent portion of the renal pelvis.

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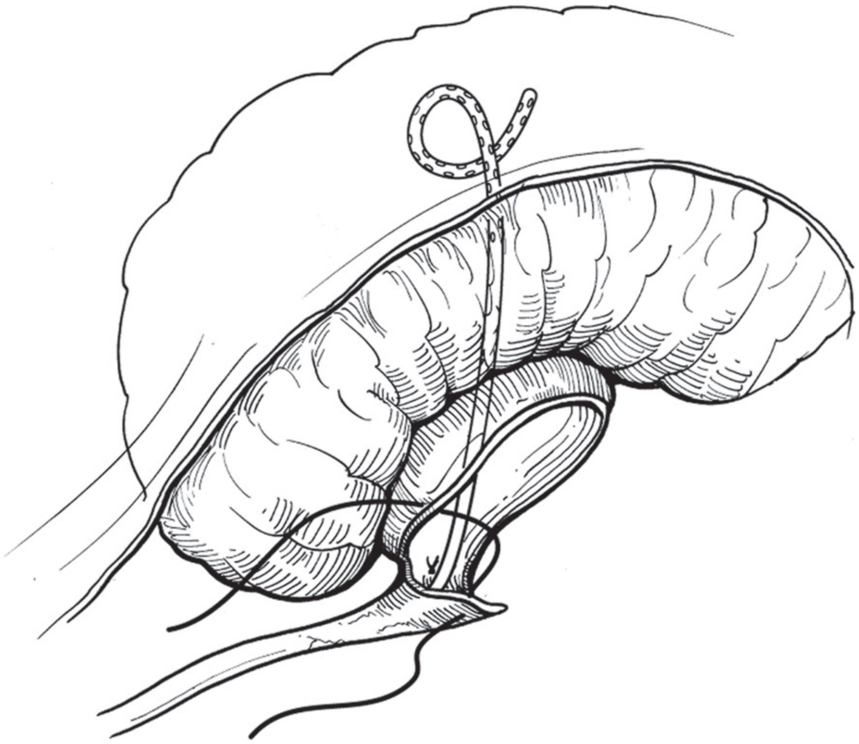

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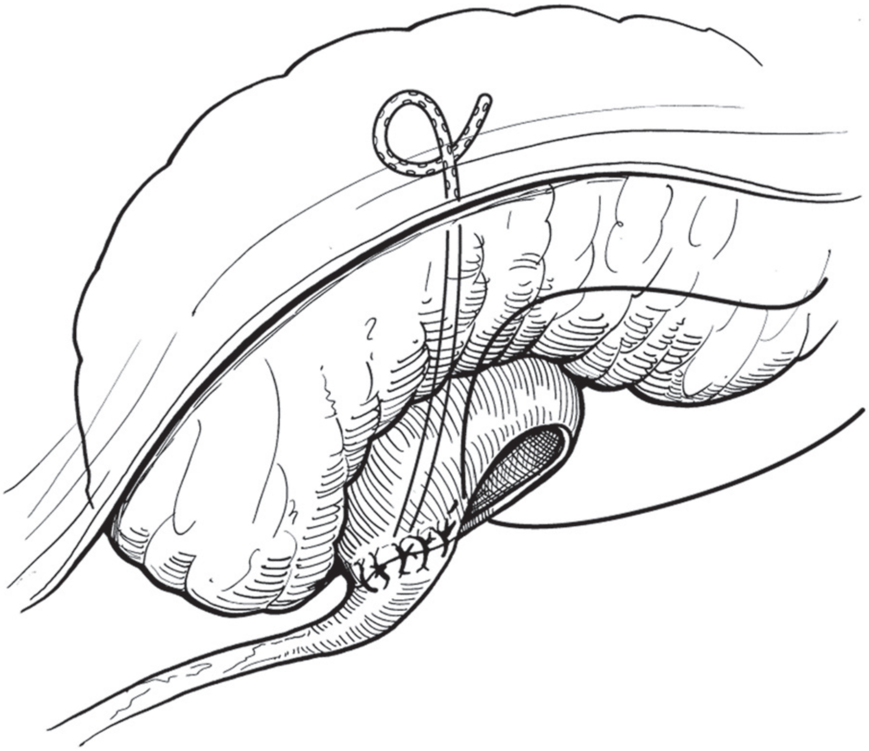


D

FIGURE 15–5, cont'd. *C*, The ureteral stent is positioned in the pelvis and the top of the ureter is sutured to the pelvis. *D*, Interrupted sutures are placed to complete the repair and the reduction pyeloplasty is closed.

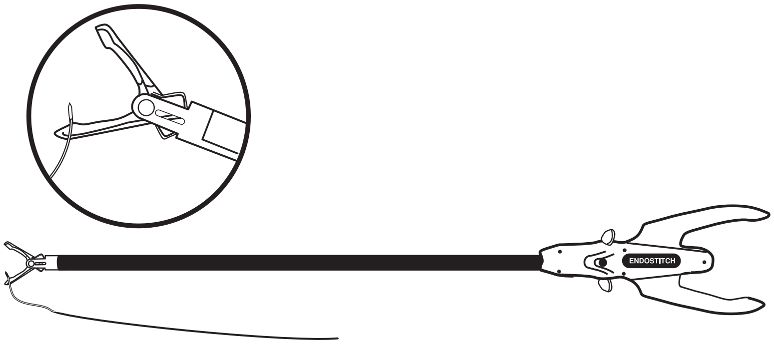


FIGURE 15–6. The EndoStitch (Auto Suture, U.S. Surgical) device allows the needle to be passed from one jaw of the instrument to the other by switching the toggle on the handle.

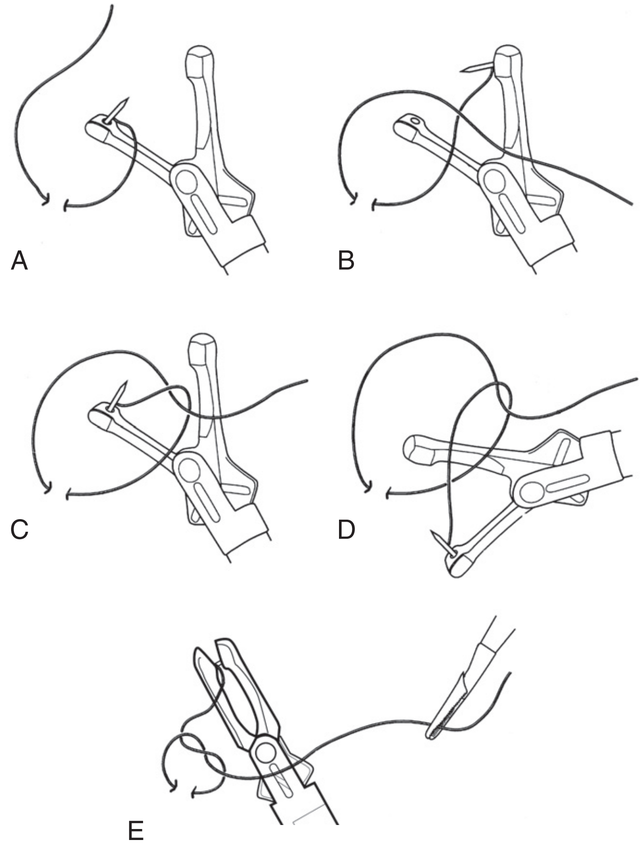


FIGURE 15–7. Suture pattern with the EndoStitch that allows rapid intracorporeal knot tying.

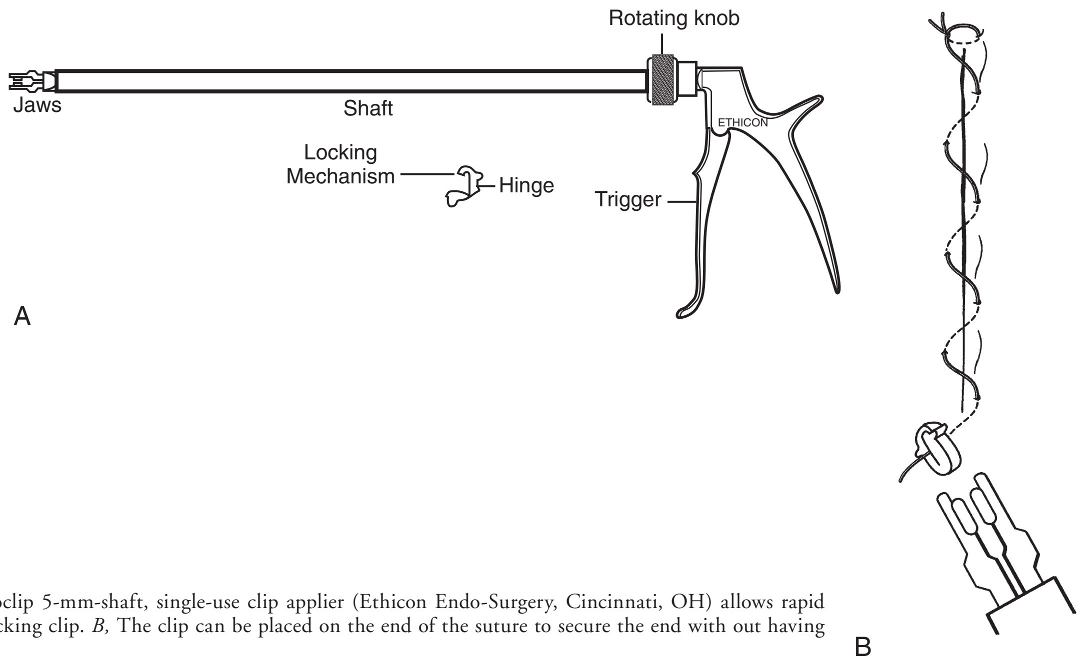
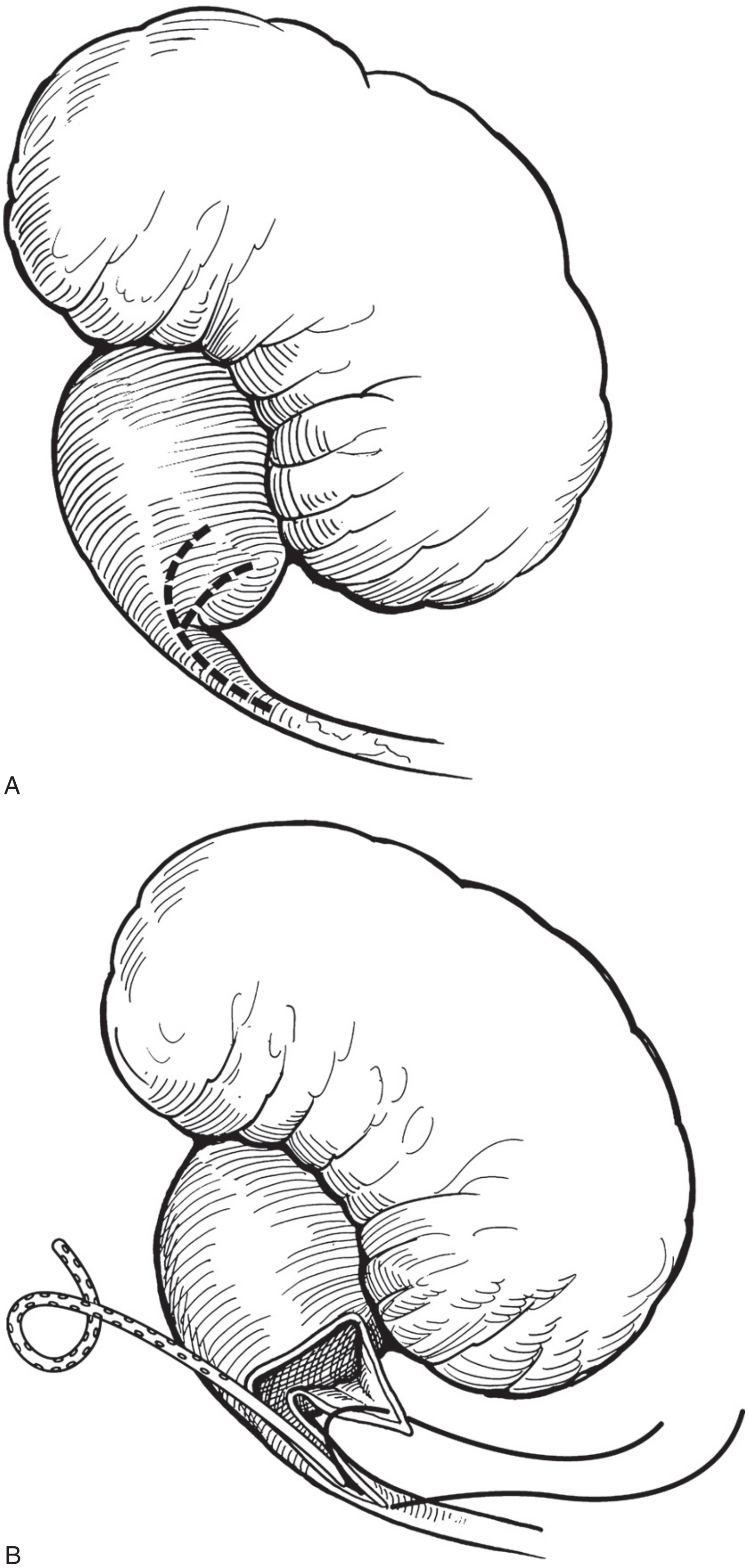


FIGURE 15–8. *A,* The Endoclip 5-mm-shaft, single-use clip applier (Ethicon Endo-Surgery, Cincinnati, OH) allows rapid placement of an absorbable, locking clip. *B,* The clip can be placed on the end of the suture to secure the end with out having to tie a knot.



A

B

FIGURE 15–9. *A,* An incision is made in the pelvis extending down on to the ureter through its insertion into the pelvis. A V is formed with arms equal in length to the incision over the ureter. *B,* A 4-0 absorbable suture is passed with the EndoStitch though the apex of the V and the apex of the ureteral incision.

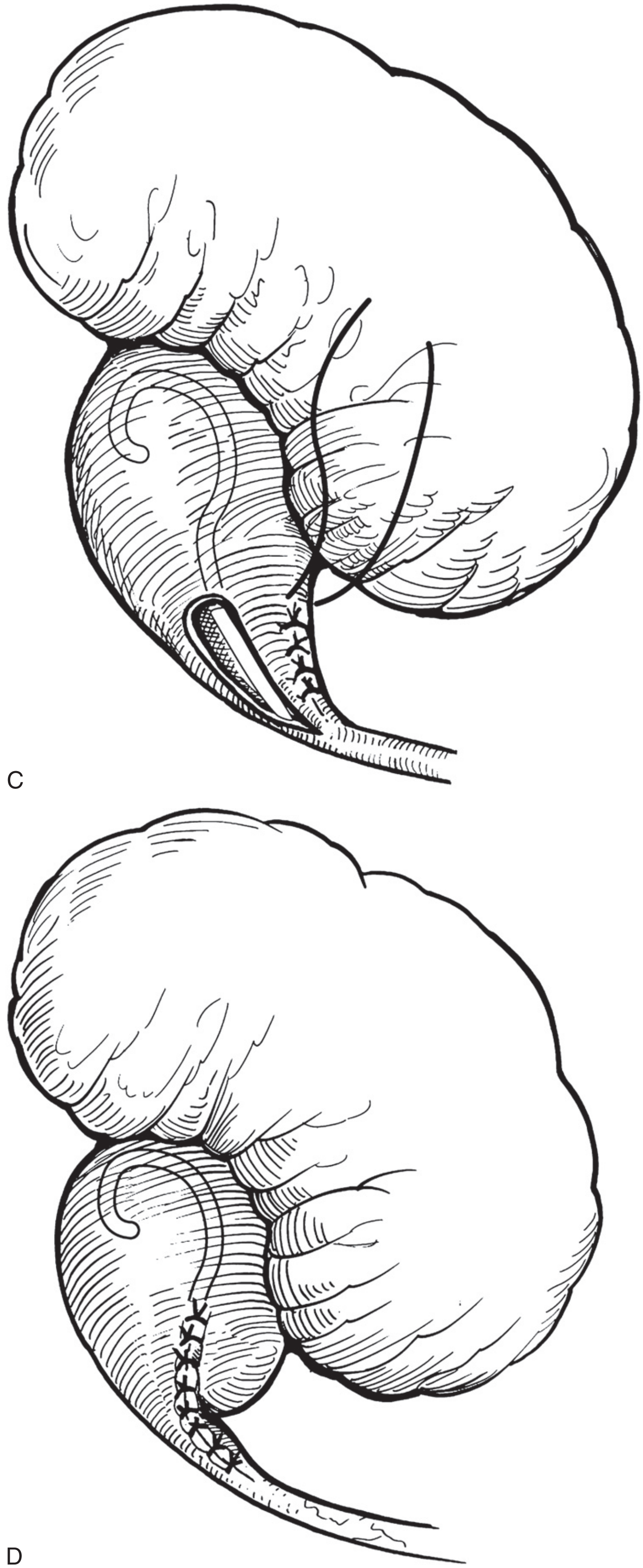


FIGURE 15–9, cont'd. *C,* The inside of the V incision is closed with a running suture. *D,* The anterior incision is closed with 4-0 absorbable suture in an interrupted or running fashion to complete the repair.

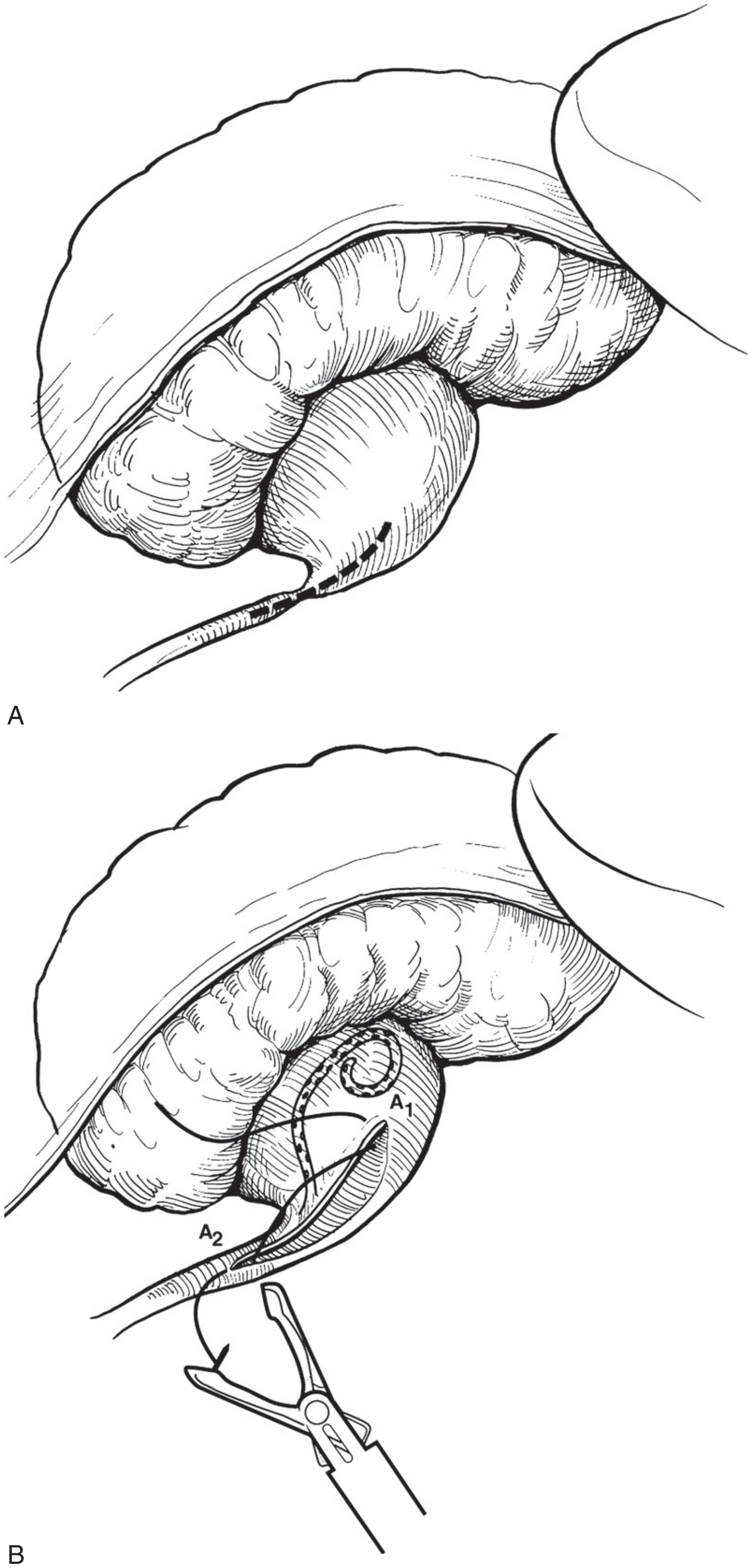


FIGURE 15–10. *A,* In the Fenger plasty repair an incision is made over the narrowed segment of the ureteropelvic junction obstruction. *B,* A 4-0 absorbable suture is placed at the superior and inferior apex of the incision A_1–A_2.

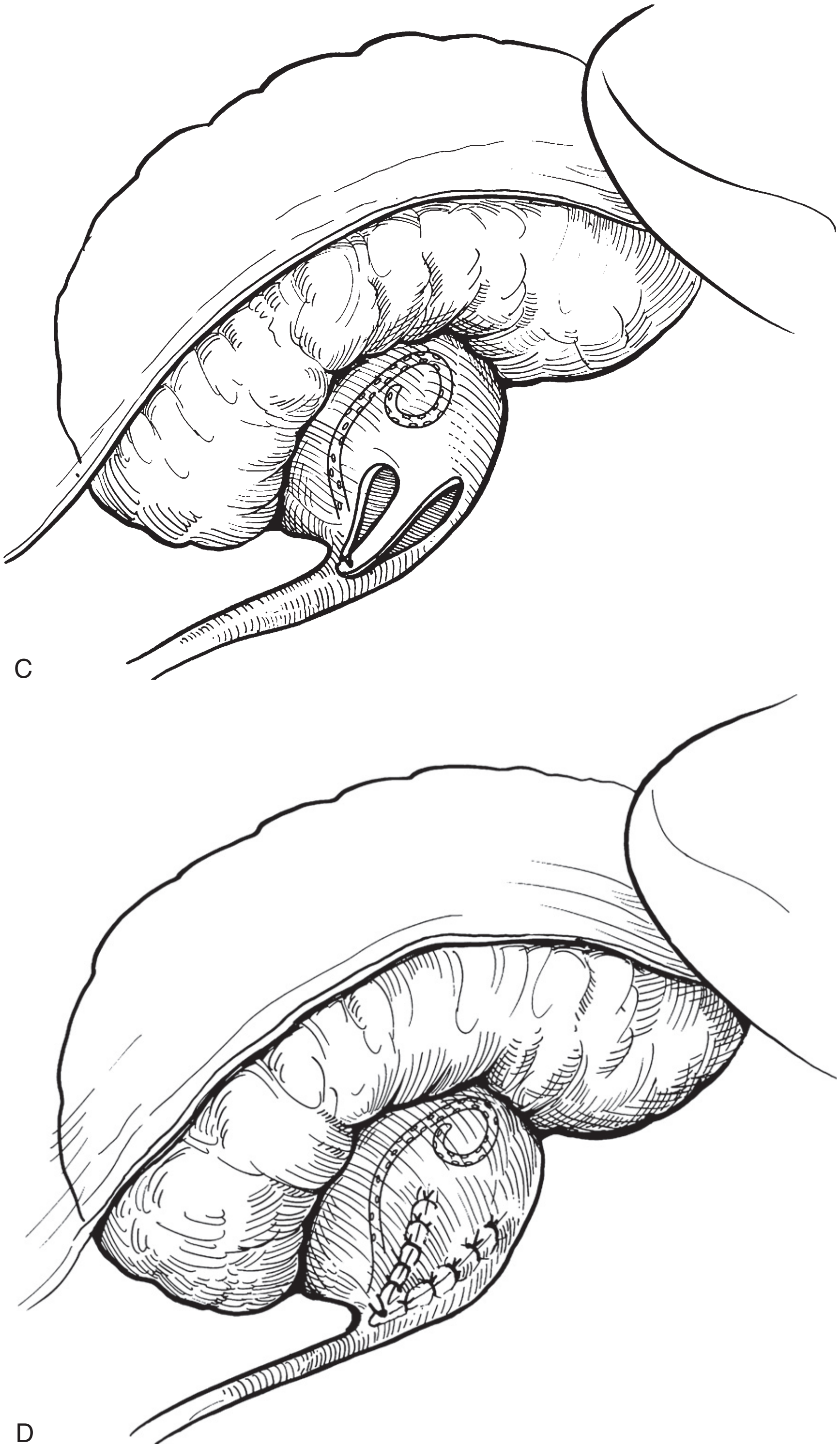


FIGURE 15–10, cont'd. *C,* The superior and inferior limits of the incision are approximated. *D,* The pelvis is now closed using interrupted suture.

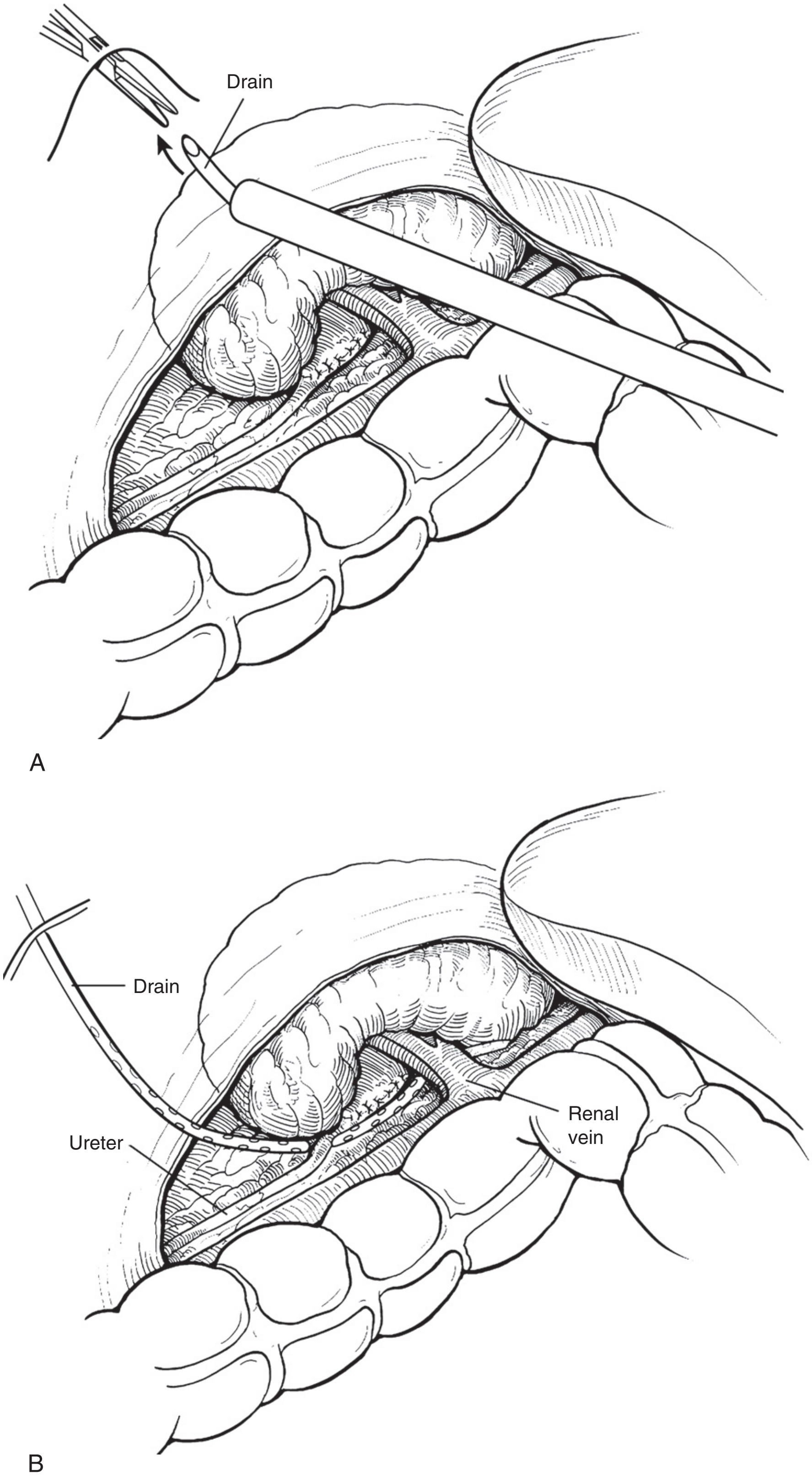


FIGURE 15–11. *A*, A hemostat is advanced through a small stab incision in the flank. The hemostat passes under the incised edge of the peritoneum. The drain is passed through one of the trocars, which had been advanced into the abdomen as far as possible and aids in directing the drain to the hemostat. *B*, The hemostat pulls the drain out of the flank incision and can then be trimmed to the appropriate length and placed under the ureteropelvic junction.

COMPLICATIONS

Anastomotic urinary leakage or formation of a retroperitoneal urinoma are uncommon complications of this procedure. Attempt conservative approach with urinary bladder catheterization and continued suction drainage. Place the drain to allow gravity to promote drainage through the collecting system. Usually, catheterization results in decreased drain output and the anastomosis heals.

Laparoscopic exploration and repositioning of the drain may be needed with large-volume urinomas or irritative peritoneal signs. Consider an evaluation including CT scan because it may indicate stent position, undrained fluid collections, or coincident pathology such as trocar hernias.

Postoperative adynamic ileus is common and usually responds to readmission and conservative treatment with intravenous fluids. Bleeding is a rare complication and is usually managed conservatively, but bleeding may necessitate administration of blood products.

Procedure failure with recurrence of the UPJ obstruction (radiologically or according to a follow-up diuretic renal scan) is more common after secondary procedures and is reported in up to 15% of secondary procedures compared with less than 5% of primary procedures. Treatment of the failed laparoscopic pyeloplasty has not been extensively studied, but endoscopic, laparoscopic, and open management have been described to be successful.[10,11]

SUMMARY

Laparoscopic pyeloplasty is an effective minimally invasive treatment for UPJ obstruction. The reconstruction may be performed with a variety of techniques, all of which require intracorporeal suturing. Morbidity is low with this procedure, and success rates are identical to open pyeloplasty. Laparoscopic pyeloplasty is an effective tool in the armamentarium of the advanced laparoscopic surgeon.

Tips and Tricks

- A high-resolution CT scan can aid in identifying crossing vessels before the operation.
- Removing a stent 1 week before the procedure may decrease ureteral edema.
- Use a long stent (7-Fr × 28 cm) so that the stent does not migrate cephalad during the reconstruction.
- If visualization is poor (obese patients), add an extra trocar for retraction.
- Vicryl clips can assist with laparoscopic knot tying.
- If anastomotic leak is suspected, check the creatinine level in the drain fluid.
- Failures occur most commonly in the first year after the procedure.

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CHAPTER 16

Laparoscopic Ureterolysis and Repair of Retrocaval Ureter

Mike Nguyen
Lars Ellison

Retroperitoneal fibrosis (RPF) is a chronic progressive inflammatory process characterized by encasement of the great vessels and extension laterally and superiorly from the level of the iliac vessels. Ureteral involvement is frequent and may result in renal dysfunction or, at the extreme, complete obstruction and anuria. Less frequent presentation patterns include spinal cord compression, bile duct obstruction, and even extension into the superior reaches of the mediastinum.

The traditional teaching is that the majority of cases are idiopathic (60%–70%).[1] A smaller percentage occurs in association with abdominal aortic aneurysm and advanced atherosclerosis. The presumed mechanism of action is leakage of insoluble lipids into the periaortic space. There have been associations made with various connective tissue disorders, vasculitides, and autoimmune disorders. In addition, there is long list of medications that are thought to have contributed to the development of this condition in specific cases. Yet there is strong evidence only for the association of methylsergide and RPF. Finally, and important, approximately 8% of RPF cases are associated with malignancy. It is important to note that RPF has never been reported as the presenting symptom of an otherwise occult malignancy.

There is mounting evidence that management with high-dose steroids tapered to low-dose maintenance is successful in as many as 85% to 87% of patients. No clinical trial data exist to support any given algorithm for medical therapy. Steroids are most effective when the disease is in a proliferative phase. During such a period, the fibrotic mass may have a large population of inflammatory cells. Alternatively, tamoxifen, with its antidesmoplastic properties, has been shown to have moderate success in reducing the size and effect of the fibrotic process.

Ultimately, surgery has been the mainstay of therapy for the definitive treatment of this condition. The basic concept of the surgical approach is to release the ureter in its length and to isolate it from further involvement in the fibrotic process. To this end, there have been numerous descriptions of how best to achieve this result. In general, there are two interrelated strategies: ureteral intraperitonealization and omental wrapping of the ureter. Next, we discuss the laparoscopic technique for intraperitonealization.

LAPAROSCOPIC URETEROLYSIS

Laparoscopic applications in urology expanded significantly in the late 1980s and early 1990s. In 1992, Kavoussi and colleagues[2] published the first description of a laparoscopic ureterolysis. In this case, a middle-aged man with right-sided ureteral obstruction secondary to RPF underwent ureterolysis with intraperitonealization of the ureter. Subsequently, further descriptions appeared in the literature outlining the importance of accepted open surgical principles as applied in the laparoscopic setting. The principles that were discussed included isolation of the ureter from the fibrotic process by intraperitonealization, omental wrapping, or preperitoneal fat wrapping[3–6]; careful dissection of the ureter emphasizing preservation of periureteral blood supply; primary repair of iatrogenic ureterotomies[7]; and the need for a high index of suspicion for occult complications in the early postoperative period.[8]

INDICATIONS AND CONTRAINDICATIONS

RPF is typically diagnosed in the fifth or sixth decade of life.[1] There is a 3:1 male-to-female ratio. The condition is quite rare in children, but it must be considered when a concomitant autoimmune condition exists. Patients typically experience symptoms for 6 to 12 months before the condition is diagnosed. Traditionally, ureterolysis has been championed as the most definitive form of therapy for RPF.

As with any laparoscopic procedure, patient selection is critical. Broadly, ureterolysis is indicated for patients who need renal units with preserved function and for those with both good performance status and a well-drained, sterile urinary tract. Specific contraindications to laparoscopic repair include but are not limited to extensive prior abdominal and pelvic surgery, prior radiation therapy to the surgical bed, an abdominal aortic aneurysm greater than 4 cm, severe chronic obstructive pulmonary disease, or significant renal dysfunction. A laparoscopic approach ultimately is reserved for patients with no involvement of the renal hilum in the fibrotic mass.

PATIENT PREOPERATIVE EVALUATION AND PREPARATION

Begin evaluation of a patient with suspected RPF with a complete history and physical examination. Important elements of the history include description and duration of low back, flank, or abdominal discomfort; weight loss; or gastrointestinal symptoms. Less common symptoms include urinary frequency, oliguria, testicular pain, edema, or gross hematuria. The physical examination tends to be unremarkable; the most common finding is hypertension. This condition is thought to be secondary to derangement in renal blood flow as a result of extension of the fibrotic process to the level of the renal vessels. Other,

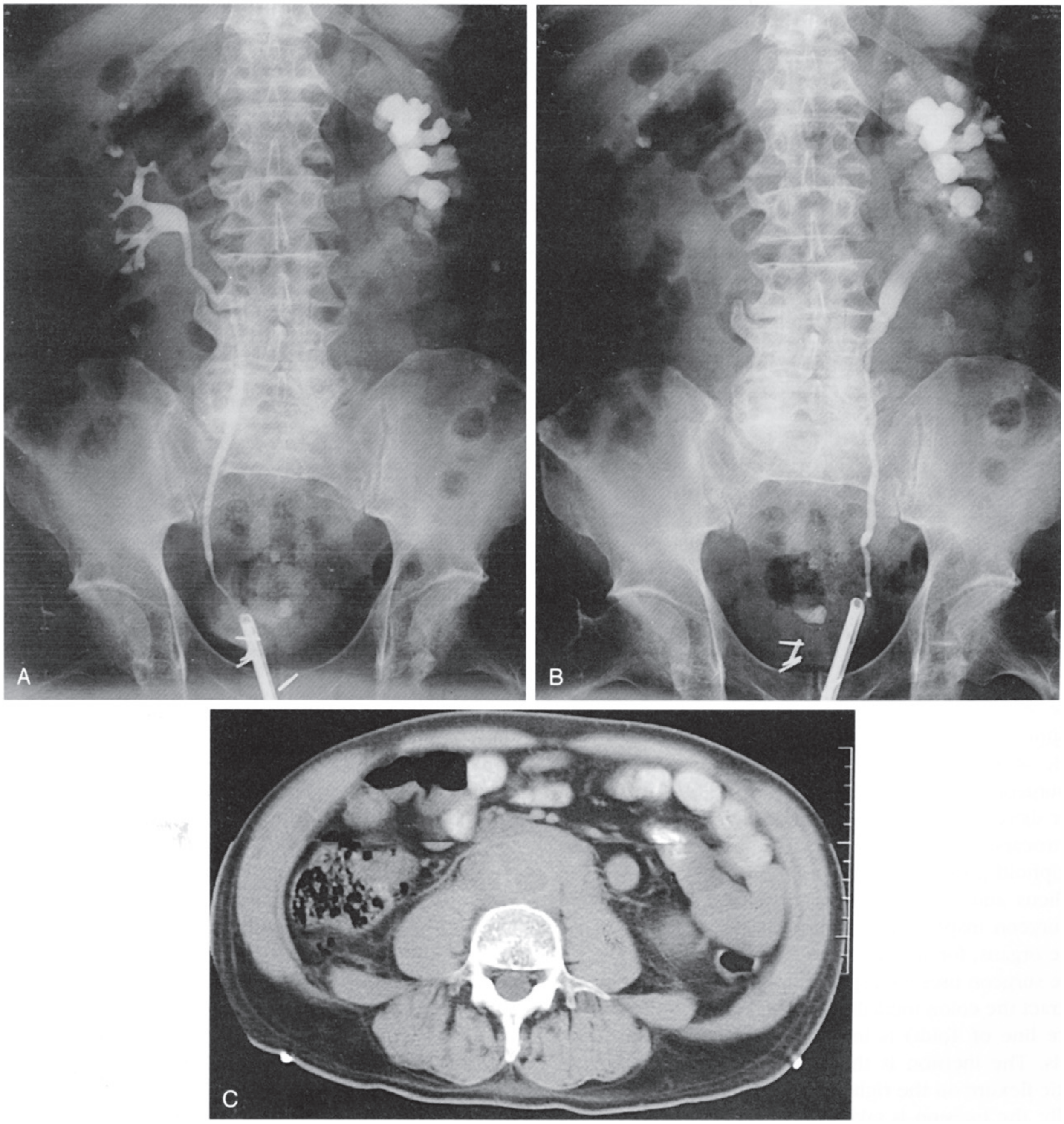

FIGURE 16–1. Retroperitoneal fibrosis. *A,* Right-sided retrograde ureterogram shows medial displacement of the mid ureteral segment. *B,* Left-sided retrograde ureterogram shows medial displacement of the ureter in the same area as the right side. *C,* A CT scan demonstrates the area of dense fibrosis causing ureteral obstruction.

less common findings all relate to relative compression of the great vessels and might include peripheral edema, ascites, hydroceles, or jaundice.

The laboratory evaluation follows a usual preoperative assessment. Specifically, patients usually have an elevated erythrocyte sedimentation rate, thrombocytosis, and mild anemia. Historically, half of patients present with elevated serum creatinine.

In the past, the radiologic study of choice was the intravenous pyelogram. This study typically demonstrated medially deviated ureters tapered to the level of obstruction. When combined with a retrograde pyelogram, the two allow for an estimation of the extent of retroperitoneal disease. However, cross-sectional imaging with either computed tomography (CT) or magnetic resonance imaging (MRI) is the new gold standard (Fig. 16–1). The additional information regarding the lateral extent of disease, relative positions of the great vessels, and radiographic appearance of the fibrotic process allow for better surgical planning. The typical description is that of a flat retroperitoneal process involving, but not displacing, the great vessels. On MRI, the T1 images typically show a low signal–intensity periaortic process.

A nuclear medicine scan may provide addition information regarding the relative renal split function. Estimation of the degree of obstruction as measured by delayed clearing of the

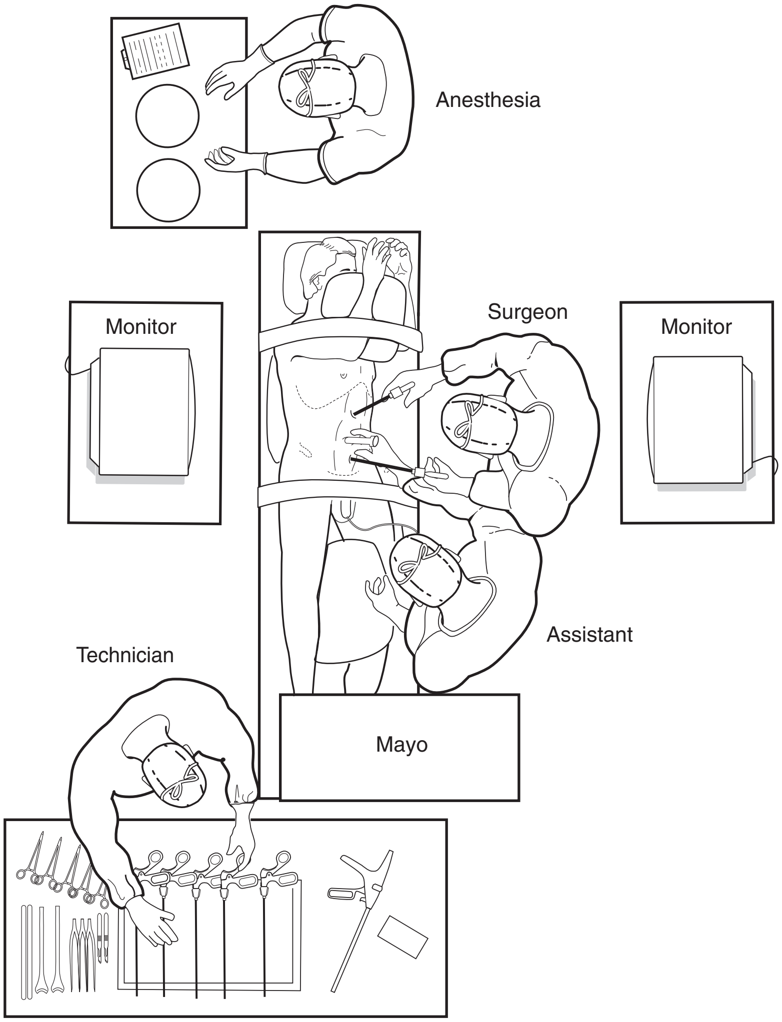

FIGURE 16–2. The operating room is configured so that all personnel can view the procedure.

renal pelvis after diuretic is more an estimation of the extent of impaired ureteral peristalsis than a function of extrinsic obstruction. This can be observed equally during ureteral stent placement. For the most part, the guidewire and stent can be advanced without resistance.

Our preoperative preparation begins 10 days before surgery, when patients stop taking all aspirin-containing products. An updated history, physical examination, laboratory work (including urinalysis and urine culture), chest radiograph, and electrocardiogram are performed within 7 days of the procedure. The day before surgery, patients take 16 ounces of oral magnesium citrate at 3:00 PM with clear liquids to follow until midnight. Patients arrive in the preoperative holding area with an empty stomach except for blood pressure medication and half their usual morning dose of insulin. All patients already had either percutaneous nephrostomy tubes or internal ureteral stents placed at the time of diagnosis.

OPERATING ROOM CONFIGURATION AND PATIENT POSITIONING

The operating team stands on the contralateral side of the affected ureter, looking over the patient directly at the video tower or boom. Place the electrocautery equipment, compression-stocking pump, and body warmer at the foot of the bed. Bring the suction-irrigator off the head of the bed. The surgical assistant stands caudad to, and the scrub nurse stands opposite, the operating surgeon (Fig. 16–2).

We perform our procedure through a transabdominal approach. Place patient in a supine position. After induction of general endotracheal anesthesia, place 6-French double-J ureteral stents using a flexible cystoscope, and confirm the position with fluoroscopy.

Place a Foley catheter, antiembolism stockings, sequential compression devices, and lower body–warming blanket. Tuck the arms and firmly secure the patient to the table. Securing the patient is very important because of the need to tilt the bed to an extreme angle to facilitate bowel mobilization (Fig. 16–3).

TROCAR PLACEMENT

Trocar placement is dependent on the distal and proximal extent of the fibrotic process and ureteral involvement. We use four 12-mm trocars. Place them in the midline beginning at the subxyphoid position and separated by 8 to 10 cm, depending on the patient's size (Fig. 16–4).

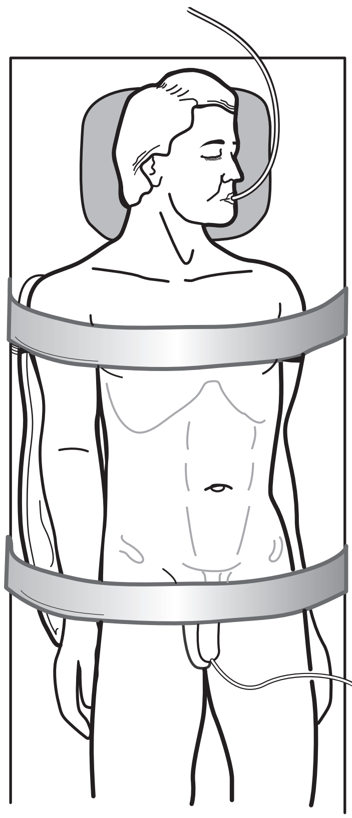

FIGURE 16–3. The patient is positioned in the supine position and secured with wide tape at the hips and shoulders to prevent slipping during rotation of the table.

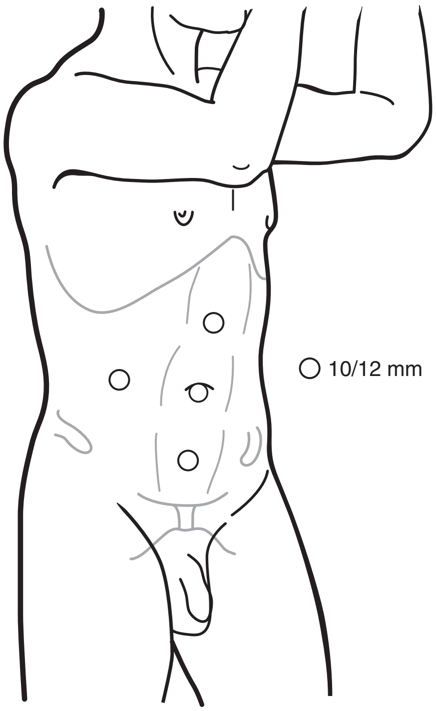

FIGURE 16–4. Trocar placement for laparoscopic ureterolysis. Two 10-mm midline ports are used. A 10-mm trocar is placed at the umbilicus. The second port is located midway between the xiphoid process and the umbilicus. A third trocar is placed between the pubis symphysis and the umbilicus. A fourth trocar is located lateral to the rectus in line with the umbilicus for retraction or aspiration.

Step-by-Step Procedure

Using a Veress needle through the umbilicus, insufflate the abdominal cavity with CO_2 to 15 cm pressure. Make a 10-mm incision approximately 2 cm superior to the umbilicus. Use a Kelly clamp to spread the subcutaneous tissue off the rectus sheath. Use a Visiport (U.S. Surgical, Norwalk, CT) with the 12-mm trocar and a 0-degree lens to enter the abdominal cavity. With the Visiport, it is important to use blunt downward pressure to reach each fascial plane. Then deploy the blade parallel to the visualized fascial fibers. Do not use excessive downward pressure because it can lead to inadvertent laceration of the bowel wall or mesenteric fat. Discard the Visiport device, and fully inspect the abdominal cavity for evidence of adhesions. Place the three additional trocars under direct vision. Secure each trocar in place at the appropriate depth with a 2-0 silk stay suture.

Tilt the operative table 45 degrees toward the operating team to facilitate mobilization of the bowel. We begin with the three superior ports and the 30-degree lens. Using blunt Maryland dissectors and the suction-irrigator, move the bowel away from the lateral side wall to expose the white line of Toldt in its entirety. At this point, it is essential to have a mental map of the extent of the dissection that will be necessary to completely release the ureter. Incise the white line with EndoShears using a combination of sharp dissection and electrocautery beginning at the iliac vessels and extending superiorly to the inferior margin of the kidney. Keeping a generous lateral sleeve of peritoneum on the bowel will facilitate the intraperitonealization of the ureter. At the inferior margin of the kidney, swing the dissection medially but just lateral to the presumed location of the renal hilum. Then carry this incision superiorly past the apex of the kidney and just lateral to the splenic hilum. On the right, follow the course of the colon around the hepatic flexure and then diagonally to the renal hilum. The dissection needs to extend only 2 cm above the renal hilum on the right.

Moving back to the caudal extent of the incision, identify the margin between mesenteric fat and retroperitoneal fat. Blunt dissection is usually adequate to mobilize the bowel medially. Once the fibrotic process is encountered, the plane of dissection becomes indistinct. Continue superiorly with the easily accomplished mobilization until with spleen has been released. This will allow the spleen to fall to a medial position, bringing along the splenic flexure of the colon.

Frame-shift the instruments to the lowest three trocars and continue the dissection below the level of the iliac vessels. Once the ureter is encountered at a position outside the fibrotic process, free the ureter of attachment and dissect it to the point of entry into the fibrosis. The renal pelvis is rarely involved and consequently is an excellent place to start the dissection (Fig. 16–5). Place a vessel loop or umbilical tape around the ureter and secure the ends together with a clip. This can then be used to manipulate the ureter in a relatively atraumatic fashion (Fig. 16–6).

At this point, the retroperitoneal mass must be exposed adequately. Obtain a series of incisional biopsies, and send them for pathologic frozen sectioning. Take care to avoid the hidden great vessels and involved ureter. A pathologic report of no malignancy allows the case to proceed as planned. Then follow the ureter in a slow and meticulous fashion into the fibrotic mass. Advance a right angle along and superficial to

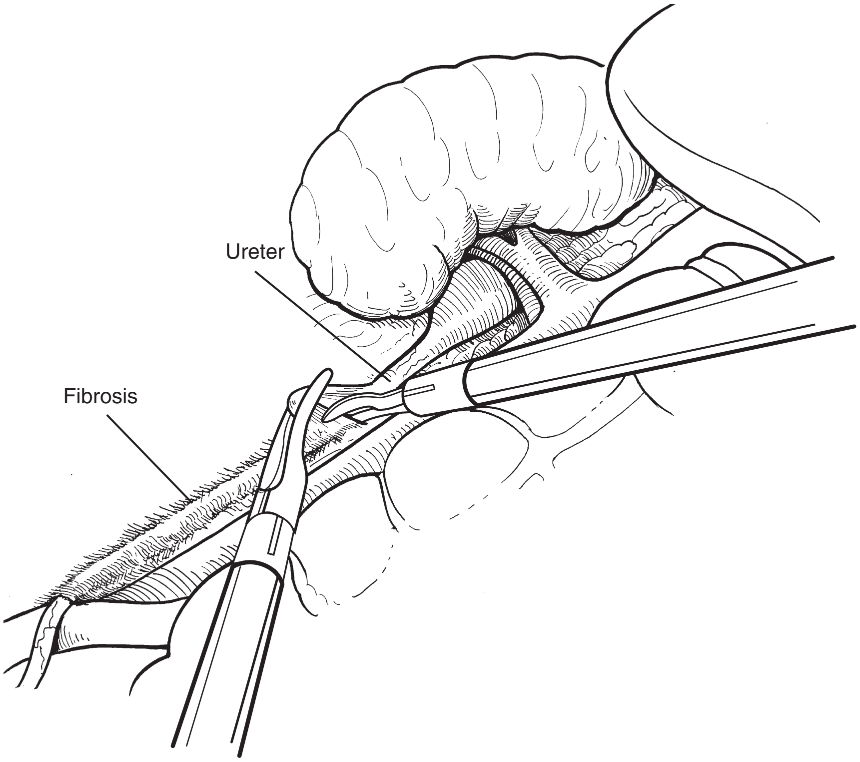

FIGURE 16–5. Once the colon is reflected, the proximal ureter is identified. Using sharp dissection, the ureter is freed circumferentially above the area of fibrosis.

the trajectory of the ureter; this will facilitate division of the mass.

It is tempting to stay right on the ureter, but do not; although this is an easier plane to follow, the result will be a devascularized ureter. This path also increases the risk of creating ureterotomies or, worse, a complete transection of the ureter. It is vitally important to avoid all forms of electrocautery during this part of the dissection. The depth of heat penetration will vary, thus putting the ureter at great risk.

Once the superior margin of the ureteral entrapment has been reached, continue mobilization of the ureter an additional 2 to 3 cm. Fully inspect the ureter along its length. In the best of hands, this is a difficult dissection that often results in multiple ureterotomies. It is vitally important to identify and repair each hole with a 4-0 Monocryl suture.

Intraperitonealization requires careful planning to both avoid ureteral kinking and to ensure isolation from the fibrotic mass. Close the trough that is left in the fibrotic mass after the ureter has been freed with suture or clips (Fig. 16–7). Bring the lateral sleeve of peritoneum that is attached to the bowel under the ureter and affix it to the psoas fascia. The wider this sleeve of tissue, the less ureteral kinking will occur from the bowel now encroaching directly on the renal pelvis. Suture the sleeve along its entire length. We use a 4-0 EndoStitch in a running fashion to achieve this goal. If desired, mobilize a piece of omentum, place it under the ureter, and secure it with a suture (Fig. 16–8).

With the repair complete, inspect and desufflate the abdomen, remove the trocars, and close the fascia with 0-0 Vicryl suture.

POSTOPERATIVE MANAGEMENT

Postoperatively, patients are allowed clear liquids that are advanced to a regular diet as tolerated. For pain management, they are given morphine-based patient-controlled analgesia. The Foley catheter is typically removed once the patient is ambulating and able to comfortably get to the bathroom. Pain management is transitioned to oral narcotics the afternoon of postoperative day 1. Most patients are ready for discharge to home the afternoon of postoperative day 2.

The ureteral stent remains in place for 4 weeks postoperatively. This can be removed in the clinic. Patients are followed with laboratory tests and imaging 2 weeks after the removal of the stent and then on a 6-month basis for 2 years.

COMPLICATIONS

The general complications that can occur with all laparoscopic procedures are discussed elsewhere.

The difficulty of the procedure cannot be understated. The density of the fibrotic process dictates how challenging the dissection will be. Although management of ureteral injury is straightforward and follows usual principles, remember that by virtue of the disease, these are frail patients with multiple comorbidities. They often have an element of renal insufficiency. Consequently, these patients may not be able to tolerate a bowel interposition graft if the ureter is substantially injured or, worse, devascularized.

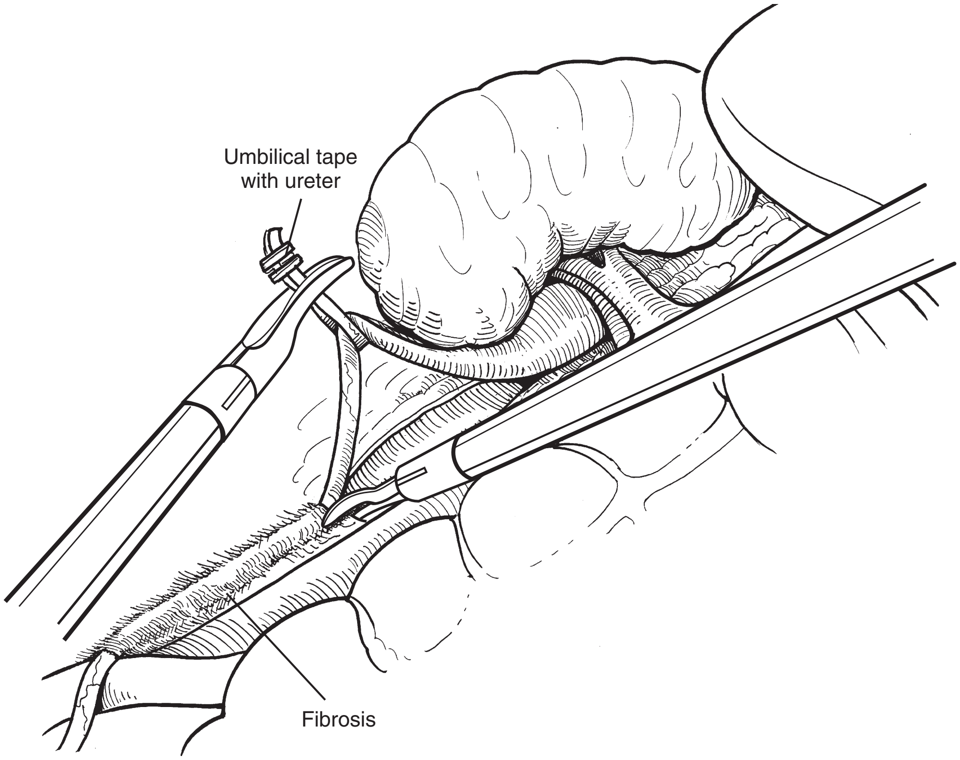

FIGURE 16–6. Traction via a clipped 6-cm piece of umbilical tape aids in dissection. As the ureter is elevated, scissors are used to open the dense fibrosis surrounding the ureter.

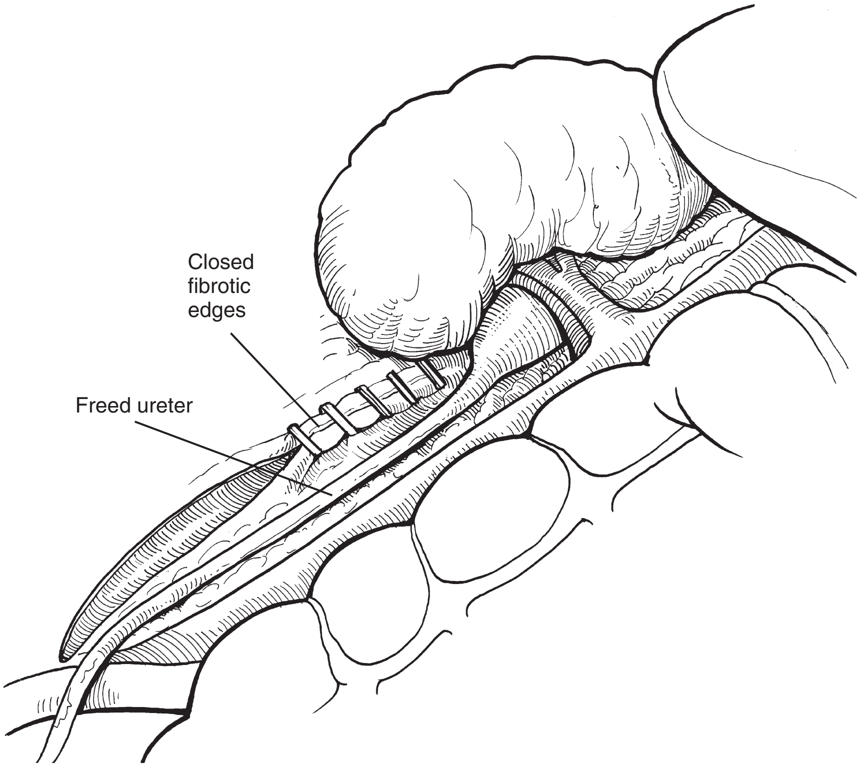

FIGURE 16–7. Reapproximating the peritoneum posteriorly with clips or a suture intraperitonealizes the ureter.

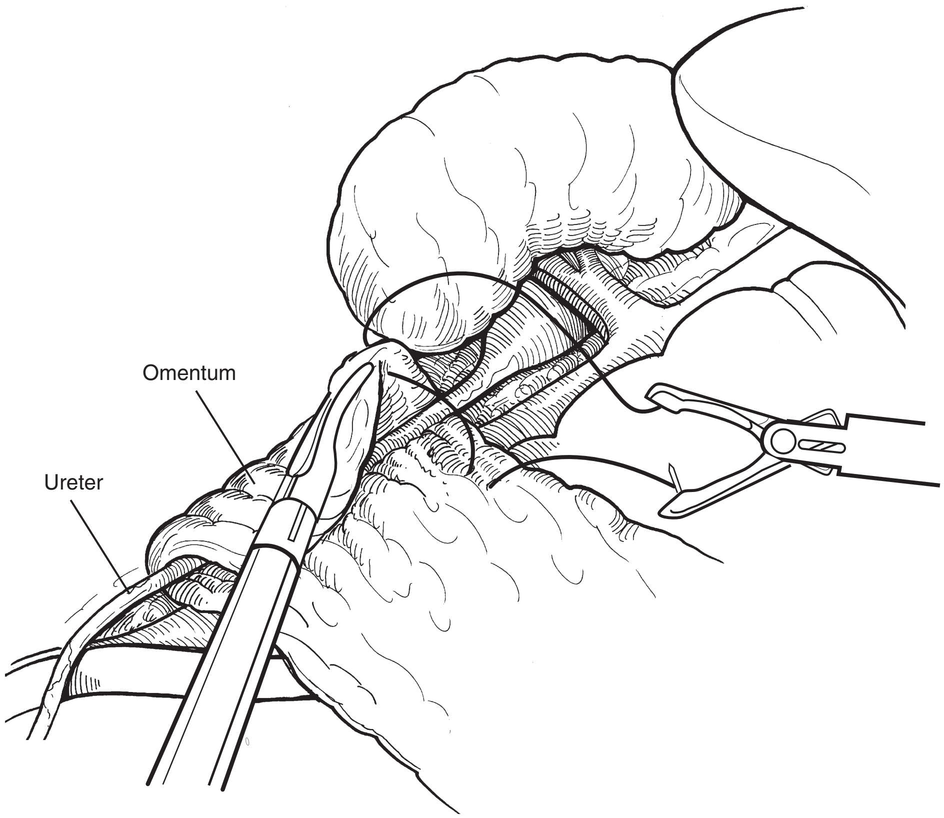

FIGURE 16–8. A flap of omentum from the transverse colon can be placed under the ureter to protect the ureter from being entrapped in fibrosis and causing obstruction.

Long-term complications include ureteral stricture, ureteral kinking, and reinvolvement of the ureter in the fibrotic mass. Stricture and kinking are primarily a result of surgical technique. With regard to reinvolvement of the ureter in the mass, some have advocated a combined therapeutic approach with the judicious use of long-term low-dose steroids.

SPECIAL INSTRUMENTS

We use a standard laparoscopic tray for this procedure. In that tray are 5-mm instruments: two Maryland dissectors, a short- and long-tip right angle, EndoShears, a suction-irrigator, and an EndoStitch device. Occasionally, we use a lap paddle to assist in bowel retraction.

Tips and Tricks

- Place four 12-mm trocars in the midline to facilitate the cephalad and caudal dissections.
- Leave a wide sleeve on the lateral aspect of the large bowel when incising the white line of Toldt.
- Pay close attention to the lie of the ureter when beginning the superior intraperitonealization. This will reduce the risk of kinking the proximal ureter.

RETROCAVAL URETER

Retrocaval ureter is a rare congenital anomaly that occurs in 1 in 1000 live births. The condition occurs when the infrarenal vena cava develops from the right posterior cardinal vein rather than from the right supracardinal vein. The end result is a proximal ureter that wraps from posterior cephalad to anterior caudad around the vena cava. The condition is limited to the right side, except in rare cases of vena caval duplication. When the retrocaval position leads to proximal hydronephrosis through compression, patients may become symptomatic.

In 1994, Baba and associates[9] described the first laparoscopic repair of a circumcaval ureter. Performed in a 54-year-old man, the procedure followed closely the principles of a dismembered pyeloplasty. They trimmed redundant ureter and performed a primary end-to-end spatulated anastomosis. Numerous descriptions of the retroperitoneal approach exist in the literature.[10–17]

INDICATIONS AND CONTRAINDICATIONS

The relative indications and contraindications to surgically managing these cases with a laparoscopic approach mimic those outlined for the management of ureteropelvic junction obstruction.

PATIENT PREOPERATIVE EVALUATION AND PREPARATION

Evaluation of a patient with suspected retrocaval ureter begins with a complete history and physical examination. Important elements of the history include timing, onset, duration, and description of symptoms. Patients often describe intermittent colicky flank pain, and often the symptoms are worse immediately after ingesting liquids or medications with diuretic properties. The physical examination may demonstrate a large mass in the right upper quadrant, but as with ureteropelvic junction, this finding is relatively uncommon.

The laboratory evaluation focuses on quantification of overall renal function. However, a complete blood cell count, serum electrolytes, urinalysis, and urine culture are important.

The radiologic study of choice has traditionally been the intravenous pyelogram. This will demonstrate a classic reverse J- or S-shape deformity. In addition to anatomic information, the intravenous pyelogram provides a crude estimation of the degree of obstruction (Fig. 16–9).

Our studies of choice are a spiral CT of the abdomen and pelvis with contrast and a MAG3 diuretic renal scan. These two studies provide us with accurate information regarding the position and course of the ureter relative to the inferior vena cava. The nuclear medicine scan provides an objective measure of obstruction and renal split function. Patients with less than 15% function on the affected side may be better managed with a laparoscopic nephrectomy.

Our preoperative preparation of these patients mimics that described for RPF patients.

OPERATING ROOM CONFIGURATION AND PATIENT POSITIONING

The operating team stands on the side contralateral to the affected ureter looking over the patient directly at the video tower/boom. Place the electrocautery equipment, compression-stocking pump, and body warmer at the foot of the bed. Bring the suction irrigator off the head of the bed. The surgical assistant stands cephalad of, and the scrub nurse stands with the table caudad to, the operating surgeon (see Fig. 16–2).

We perform our procedure through a transabdominal approach. Place the patient in a supine position. Induce general endotracheal anesthesia. Using a flexible cystoscope, place a 6-French double-J ureteral stent and confirm the position with fluoroscopy.

Place a Foley catheter, antiembolism stockings, sequential compression devices, and lower body–warming blanket. Tuck the arms, and firmly secure the patient to the operative table (Fig. 16–10). Securing the patient is very important because of the need to tilt the bed to an extreme angle to facilitate bowel mobilization.

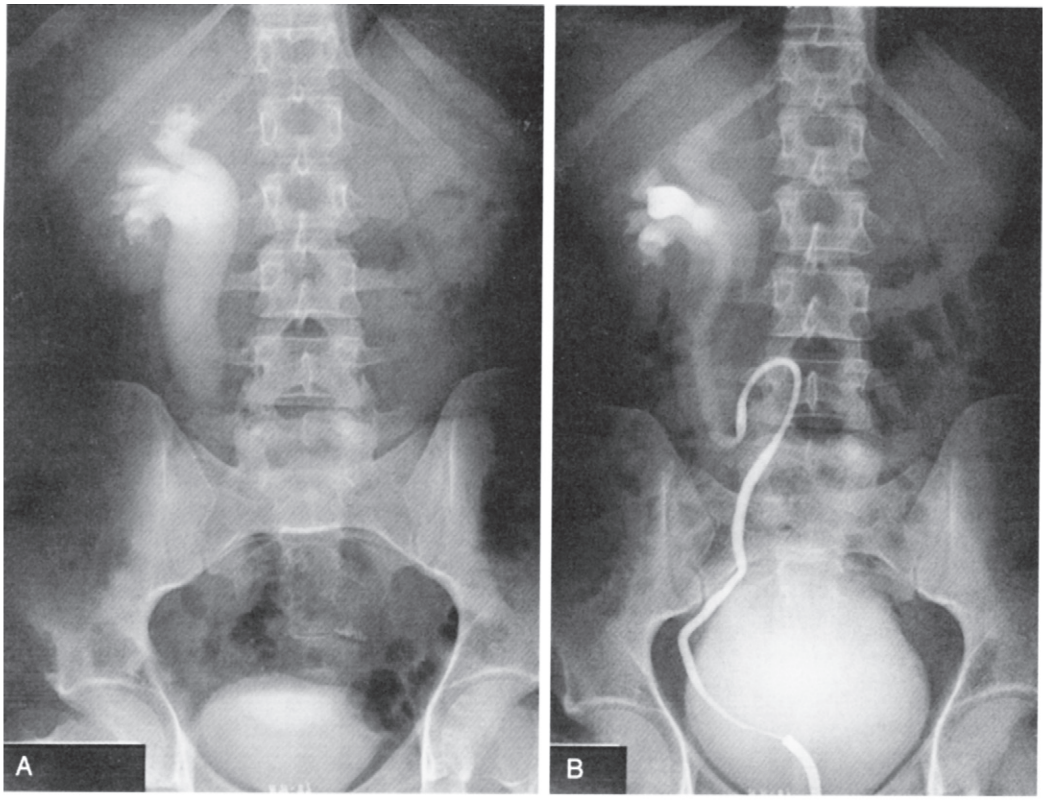

FIGURE 16–9. Circumcaval ureter. *A,* Delayed film from intravenous pyelogram shows obstruction of the upper ureter with significant hydronephrosis. *B,* Retrograde ureterogram shows the abnormal course of the ureter under the vena cava.

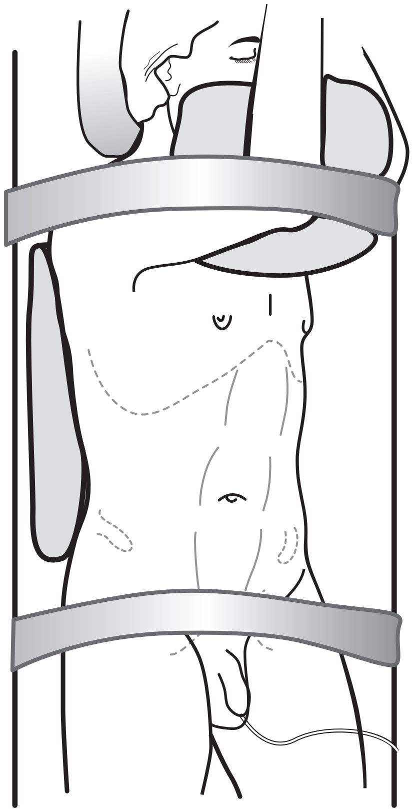

FIGURE 16–10. The patient is placed in a slight lateral position with a chest and buttocks roll placed.

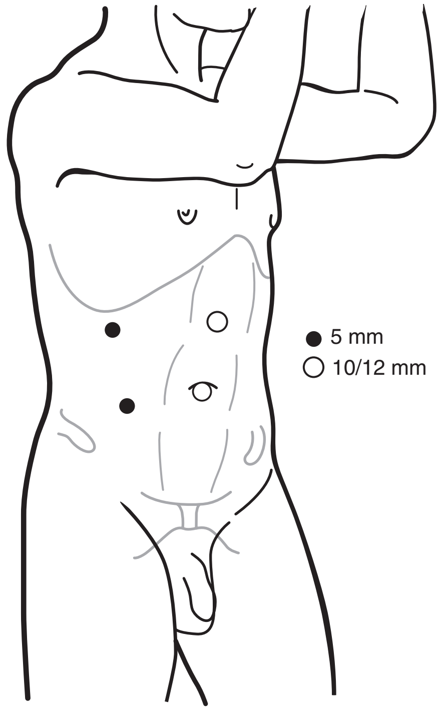

FIGURE 16–11. Three or four trocars are used with a 10-mm umbilical port for the camera. A 10-mm trocar is placed midway between the umbilicus and the xyphoid process, and a 5-mm trocar is lateral to the rectus in line with the umbilicus. An additional 5-mm trocar can be placed in the subcostal area for retraction as needed.

TROCAR PLACEMENT

Trocar placement follows a standard template. We use three 12-mm trocars. Locate the camera port at the umbilicus. Place the superior port in the midline approximately 10 cm superior to the umbilicus. Place the lateral port along the arcuate line approximately 10 cm lateral to the umbilicus (Fig. 16–11).

Step-by-Step Procedure

Using a Veress needle through the umbilicus, insufflate the abdominal cavity with CO_2 to 15 cm pressure. Make a 10-mm incision at the lateral port site. Use a Kelly clamp to spread the subcutaneous tissue off the fascial sheath. Using a Visiport with the 12-mm trocar and a 0-degree lens, enter the abdominal cavity. Place the two remaining ports at the appropriate positions under direct vision. Secure each trocar in place at the appropriate depth with a 2-0 silk stay suture.

Tilt the operating table 45 degrees toward the operating team to facilitate mobilization of the bowel. With the 30-degree lens, Maryland dissectors, and the suction-irrigator, move the bowel away from the lateral side wall to expose the white line of Toldt in its entirety. Then incise the white line with EndoShears using a combination of sharp dissection and electrocautery beginning at the iliac vessels and extending superiorly to the hepatic flexure and then diagonally to the renal hilum (Fig. 16–12).

Identify the interface between mesenteric fat and retroperitoneal fat. Medially mobilize the bowel and its mesentery to expose the interface between Gerota's fascia and the psoas muscle (Fig. 16–13). Then elevate Gerota's fascia off the psoas. Isolate the gonadal vein and drop it onto the psoas. Develop the interface between Gerota's fascia and the psoas, knowing that the ureter will begin to course medially and over the vena cava. Once this level is reached, drop Gerota's fascia and carry a more superficial dissection toward the renal hilum. Take great care at this level to sharply release the duodenum from the plane of dissection (Fig. 16–14). Once this is accomplished, the vena cava is readily visible. Identify the dilated renal pelvis and proximal ureter by their emergence from under the renal vein and their medially directed course (Fig. 16–15).

With the distal ureter dissected free of the anterior surface of the vena cava and the proximal ureter mobilized to the greatest extent possible from the medial and posterior vena cava, shift attention to planning for the reconstruction. It is critical to assess the length of the ureter. It is quite unlikely that dividing the ureter in one location will be adequate. More likely, divide the ureter in two locations, leaving the intervening posterior vena caval segment in situ. It is quite important to maintain adequate length to allow for an end-to-end spatulated repair. In addition, given that a ureteral stent is in place, it is critical to not cut or nick the stent during division of the ureter. Retract the stent from the renal pelvis rather than the urinary bladder.

After advancing the stent back into the renal pelvis, we perform our anastomosis. The anastomosis is done with free suturing or with the EndoStitch device using two running stitches, one for the posterior wall and one for the

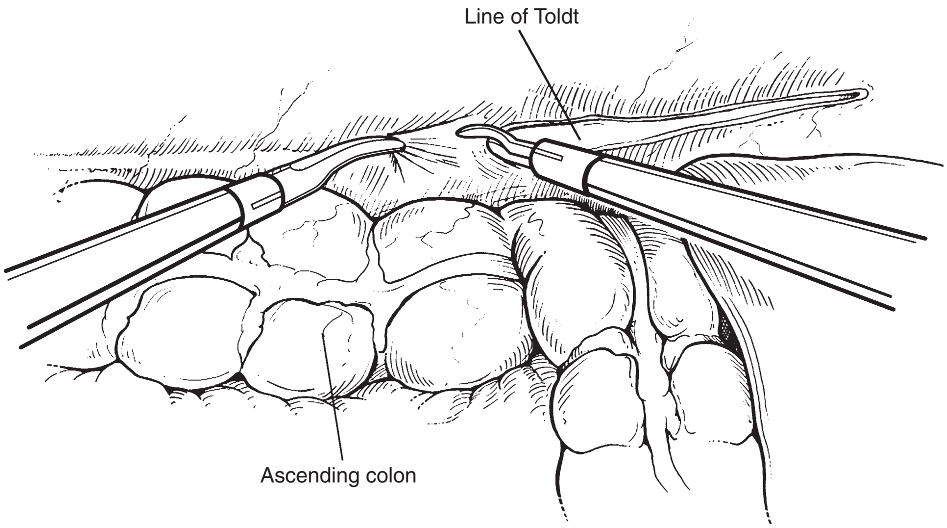

FIGURE 16–12. On the right side, the line of Toldt is sharply incised. Once the peritoneum has been opened, the colon can be reflected medially.

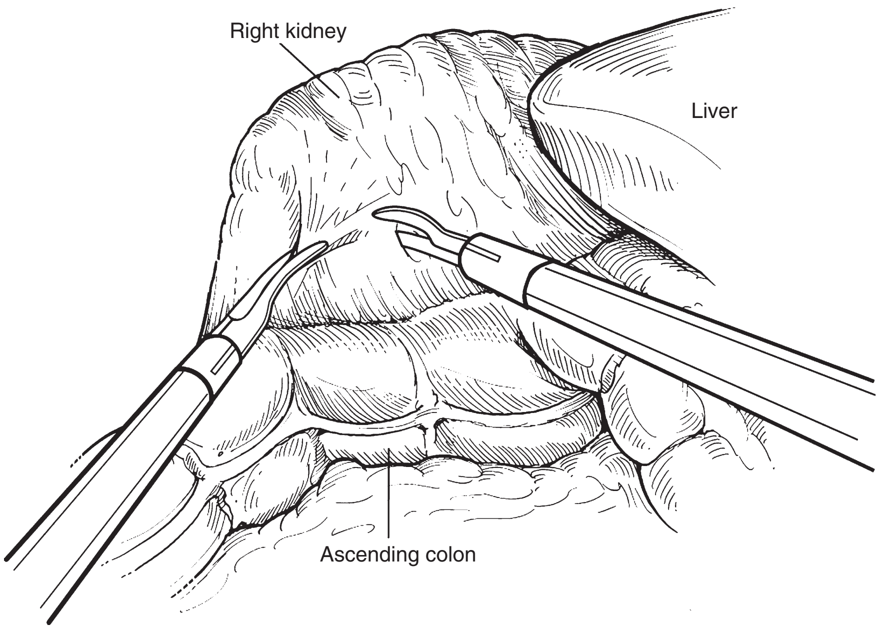

FIGURE 16–13. Renocolic attachments can be identified by medial traction on the colon and are sharply divided.

anterior wall. Place one clip using a Lapra-Ty absorbable suture clip applier (Ethicon, Cincinnati, OH) at the end of the suture to avoid the need for intracorporeal knot tying (Fig. 16–16).

Once the anastomosis is complete, place a Jackson-Pratt drain in the right upper quadrant, desufflate the abdomen, remove the trocars, and close the fascial defects.

POSTOPERATIVE MANAGEMENT

Postoperatively, patients are allowed clear liquids that are advanced to a regular diet as tolerated. For pain management, they are given morphine-based patient-controlled analgesia. Pain management is transitioned to oral narcotics the afternoon of postoperative day 1. The Foley catheter is typically removed the morning of postoperative day 2. If the Jackson-Pratt drain output remains low and unchanged for the immediate 8 hours after Foley catheter removal, then it is also removed. Most patients are ready for discharge to home the afternoon of postoperative day 2.

The ureteral stent remains in place for 4 to 6 weeks postoperatively. The stent can be removed in the clinic. Patients are usually followed with laboratory tests and imaging 1 to 2 weeks after the removal of the stent and then on a 6-month basis for 2 years.

COMPLICATIONS

The general complications that can occur with all laparoscopic procedures are discussed elsewhere.

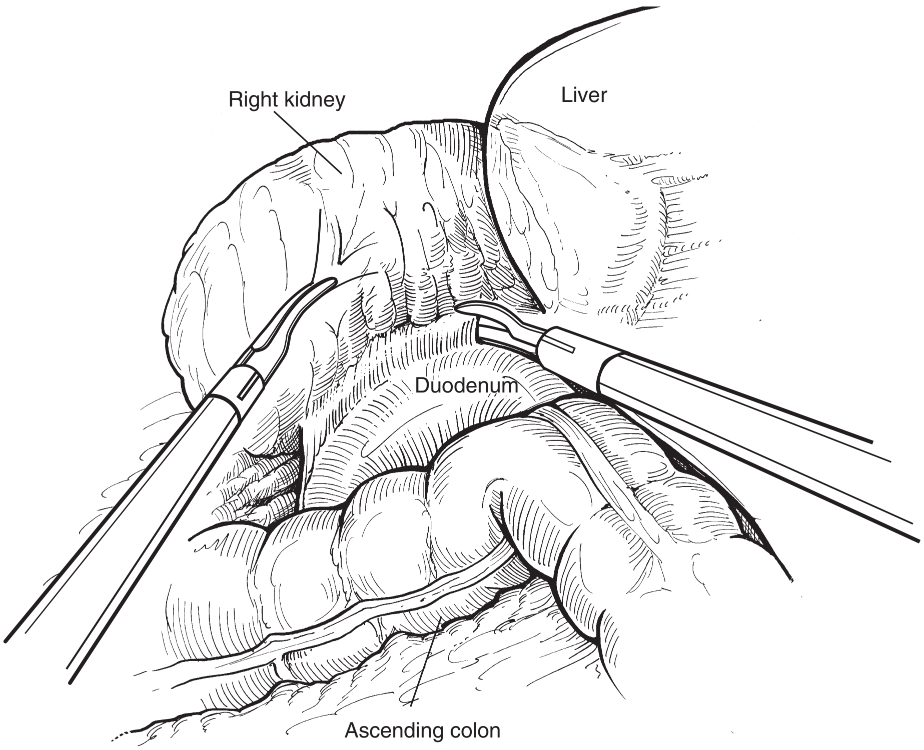

FIGURE 16–14. When the duodenum is found to obstruct the view of the renal pelvis and ureter, a Kocher maneuver is performed to complete mobilization of the bowel, exposing the inferior vena cava.

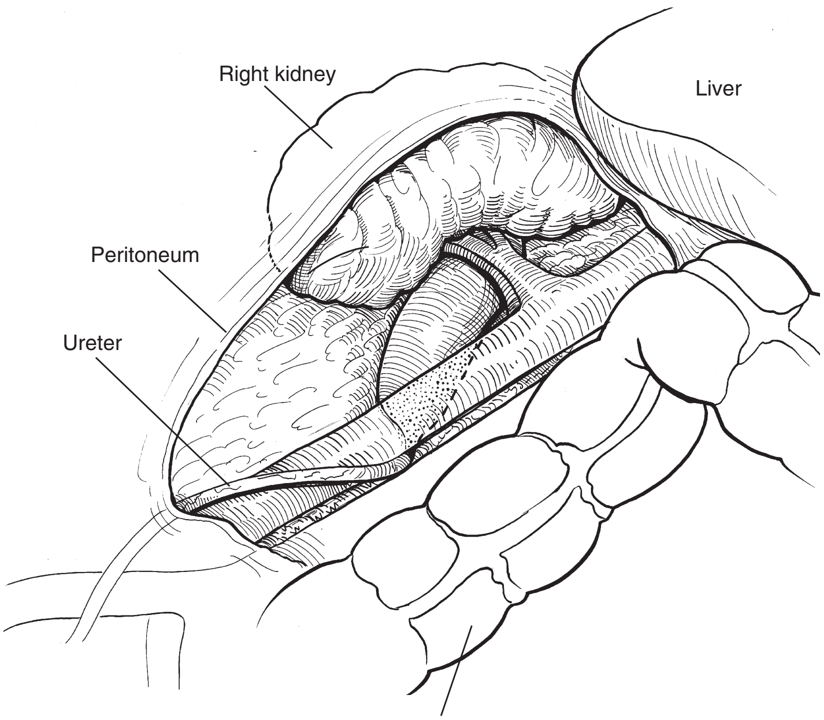

FIGURE 16–15. The lower pole of the kidney is located and elevated with a grasper, while the pelvis and ureter are identified and followed to the inferior vena cava.

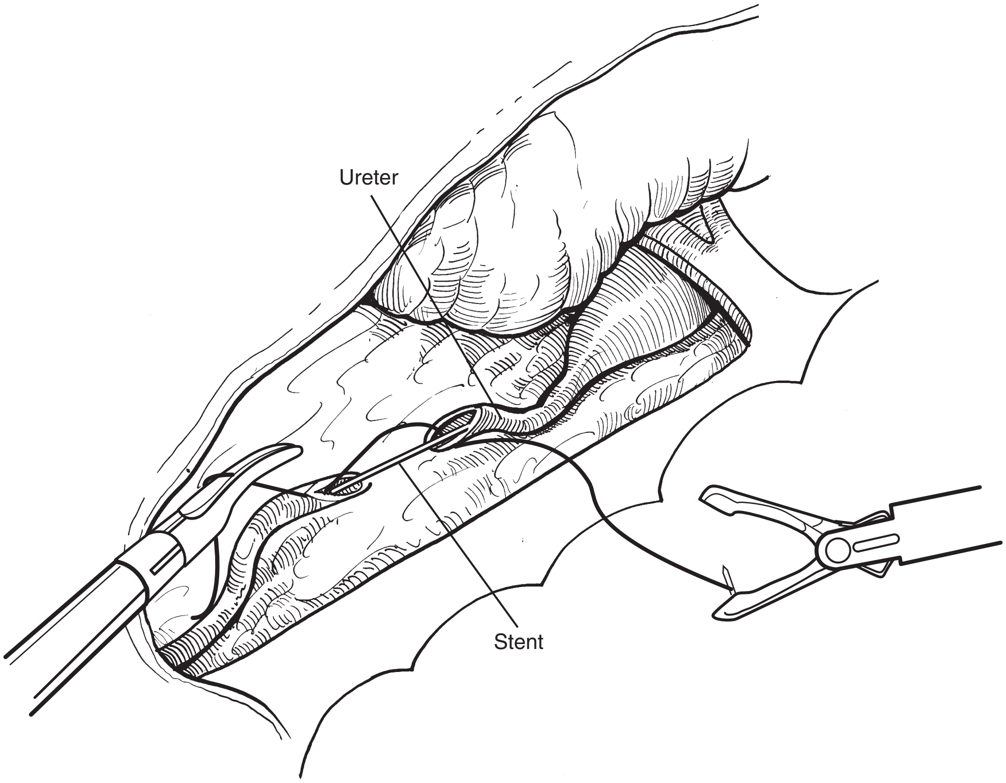

FIGURE 16–16. The ureter is mobilized and divided. The free ends of the distal ureter are dissected from the inferior vena cava and spatulated. A 4-0 absorbable suture is used to approximate the ureter. Redundant ureter or pelvis can be excised as needed.

Long-term complication is limited to ureteral stricture. Stricture is a direct result of surgical technique. Management of this situation is discussed in detail elsewhere.

SPECIAL INSTRUMENTS

We use a standard laparoscopic tray for this procedure. In that tray are 5-mm instruments: two Maryland dissectors, a short- and long-tip right angle, EndoShears, a suction-irrigator, and an EndoStitch device.

Tips and Tricks

- Use a long ureteral stent to reduce the chance of advancing the distal curl out of the bladder and into the distal ureter.
- Use a LapraTy to fix the ends of sutures. This avoids the need for intracorporeal knot tying.
- Avoid the temptation to retrieve the posterior caval ureter. The inadvertent avulsion of a lumbar vein will quickly require conversion to open surgery.

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CHAPTER 17

Laparoscopic Ureterolithotomy

Ioannis Varkarakis
Charalambos Deliveliotis

With the use of extracorporeal shockwave lithotripsy (ESWL) and the advances made in flexible ureteroscopy and laser, ultrasonic, and electrohydraulic lithotripsy devices, treatment of ureteral stones with open surgery is very rare. Open surgery is reserved for impacted stones for which these techniques fail or in cases in which the expensive equipment that is required is not available. Patients may also option for open surgery if treatment in one session is wanted, and this is unlikely to happen with the less invasive treatment modalities mentioned. In addition, open surgery for other pathologic conditions of the urinary tract may lead to simultaneous therapy of the ureteral stone. Laparoscopic ureterolithotomy is an alternative to open treatment and has exactly the same indications.

From the first laparoscopic ureterolithotomy reported in 1992 by Rabou and associates[1] and the initial isolated reports,[2–5] series of up to 24[6] and 21[7] patients have been published. The numbers are not very high, but this reflects the number of patients for whom endoscopic management of lithiasis fails.

PATIENT PREOPERATIVE EVALUATION AND PREPARATION

A non–contrast-enhanced computed tomography[8] provides information about the size and position of the stone. A plain kidney, ureter, bladder film and an intravenous pyelogram will help localize the stone, provide a rough idea about the stone consistency, and give details about the ureteral anatomy. If a ureteral stricture is suspected, a retrograde pyelogram can be performed.

OPERATING ROOM CONFIGURATION AND PATIENT POSITIONING

The operating room is configured so that there is ready access to the instruments and visualization of the procedure by all members of the surgical team (Fig. 17–1).

For the transperitoneal approach, place the patient in a lateral position for upper and midureteral stones. For stones located in the lower third of the ureter, place the patient in the supine position with slight contralateral rotation.

For the retroperitoneal approach, place the patient in the flank position.

TROCAR PLACEMENT

Transperitoneal Approach

For proximal and midureteral stones, place three trocars in line: one 10- to 12-mm umbilical port for the laparoscopic camera, one 10- to 12-mm port in the midline between the pubis and the umbilicus, and one 5-mm port in the midline between the xiphoid and the umbilical port (Fig. 17–2). Alternatively, place the two instrument ports on the ipsilateral midclavicular line (one subcostal and the other in the lower quadrant). A fourth trocar can be placed on the anterior axillary line if necessary, forming, with the other three trocars, a diamond-shaped configuration.

For lower-third ureteral stones, use four trocars: one at the umbilicus, one on the ipsilateral side supraumbilically at the midclavicular line, and two contralateral to the stone in the midclavicular line (one at the level of the umbilicus and the other in the lower quadrant). A fifth trocar can be placed in the suprapubic area if necessary.

Retroperitoneal Approach

Make a small incision at the tip of the 12th rib, through which the retroperitoneal space is balloon dissected. If the stone is located lower, reposition the balloon dissector so that dissection continues more distally. Place the first port in this incision. Place two or three more ports with a combination of direct vision and manual guidance. Place one 5- to 10-mm port at the superior edge of the iliac crest, and place another 10-mm trocar 1 palm-breadth higher than the previous one and over a line that passes over a standard subcostal incision. Place the last trocar (5 mm) on the same vertical line as the previous one but 1 palm-breadth higher (Fig. 17–3).

PROCEDURE

Both the retroperitoneal and transperitoneal approaches have been used with success. In both approaches, preoperatively place a ureteral stent to help locate the ureter. This is not always necessary because the ureter may be identified from the bulging caused by the stone itself. Some advocate simply leaving a guidewire at the tip of the stone if the ureteral stent cannot bypass the impacted calculus, with the intention to facilitate subsequent double-J stent placement after ureterotomy and stone extraction (Fig. 17–4).

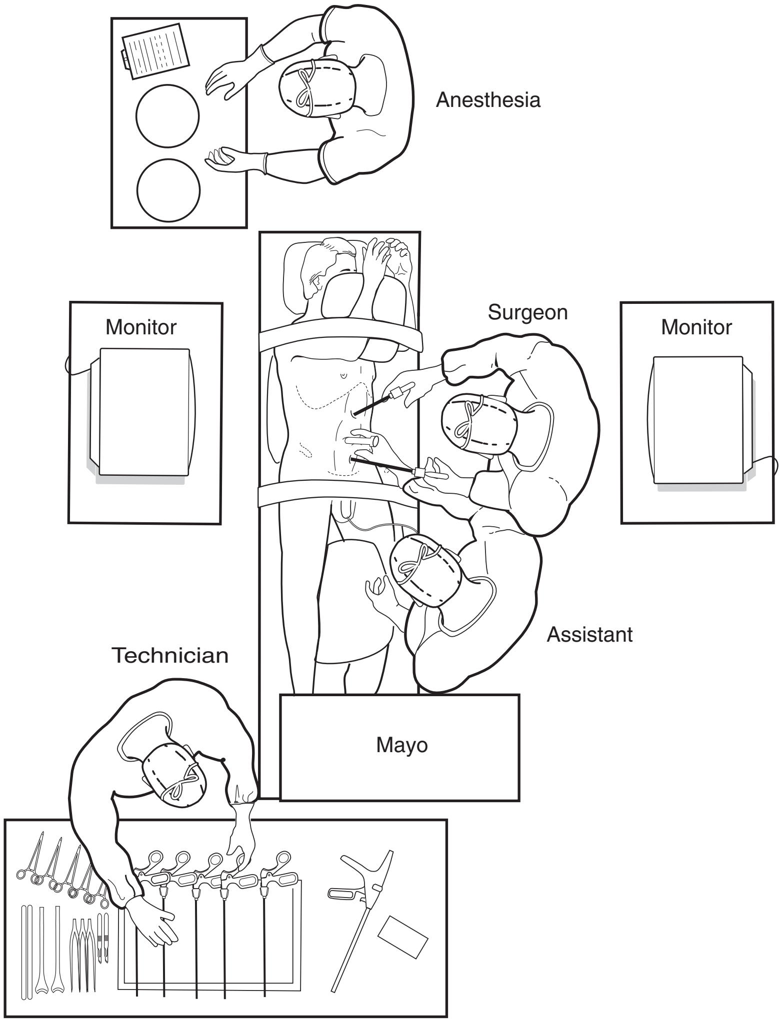


FIGURE 17–1. To allow visualization of the procedure by all members of the surgical team, the surgeon and assistant stand on the side contralateral to the pathology. The scrub nurse or technician stands on the opposite side to help with management of instrumentation.

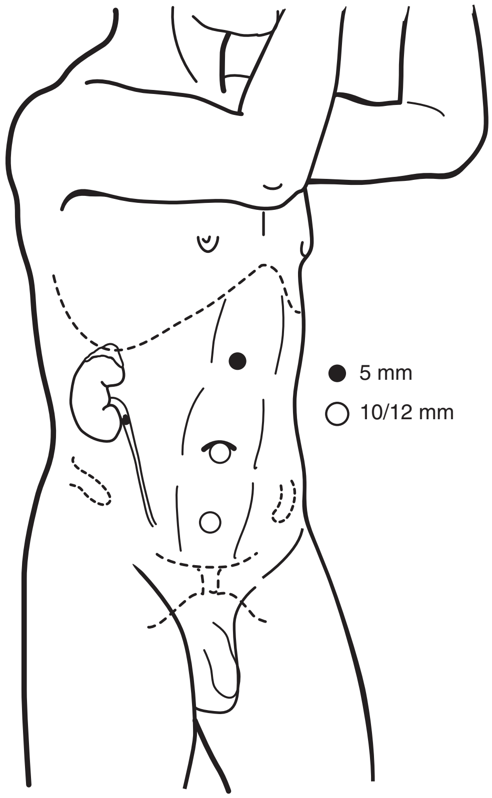


FIGURE 17–2. Trocar placement in the laparoscopic approach to a proximal ureteral calculus. Three midline trocars are placed. A 10-mm port is placed at the umbilicus. Two additional 5-mm or 10-mm ports are then placed under direct vision at the umbilicus and midway between the umbilicus and the xiphoid process.

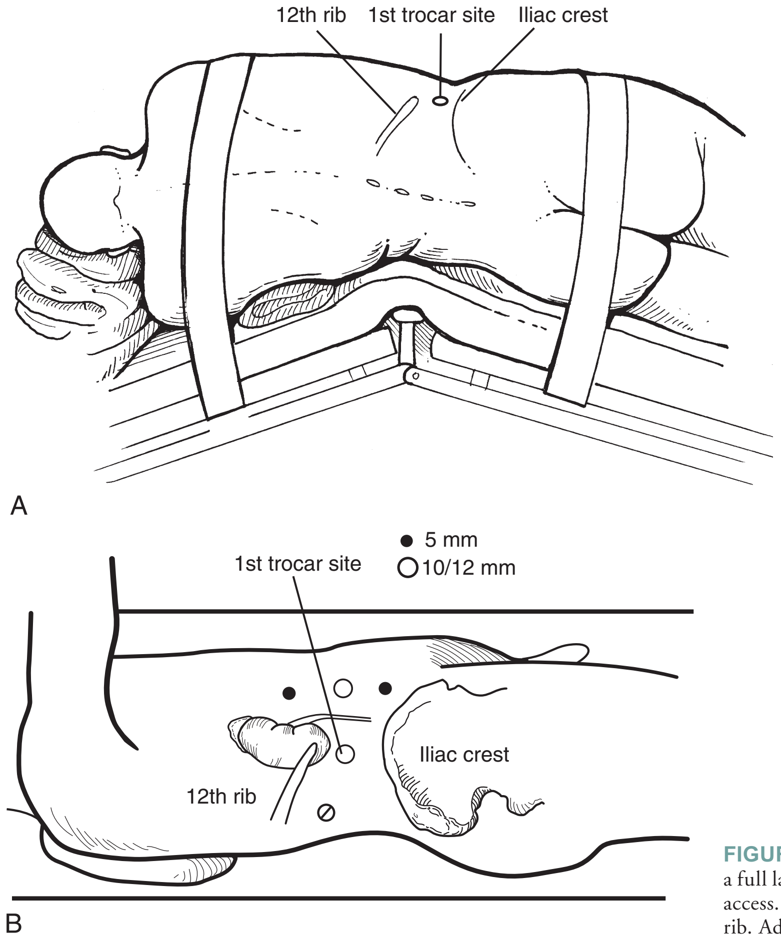


FIGURE 17–3. *A,* In the retroperitoneal approach, the patient is placed in a full lateral position. *B,* Trocar configuration for right-sided retroperitoneal access. The first trocar site is approximately 2 fingerbreadths below the 12th rib. Additional trocars are placed as needed for dissection and retraction.

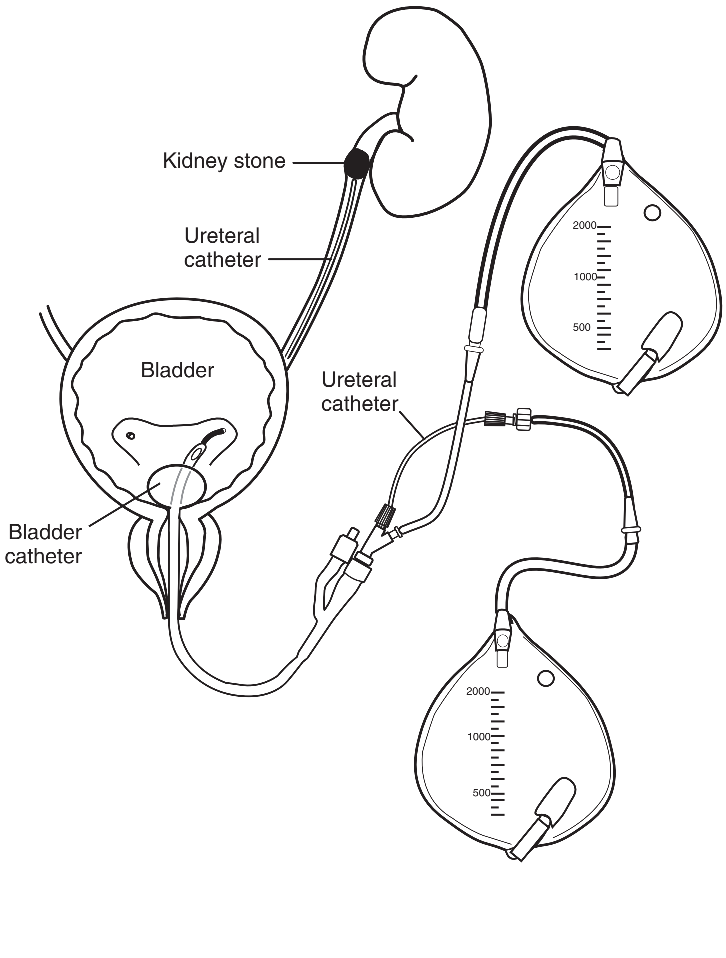
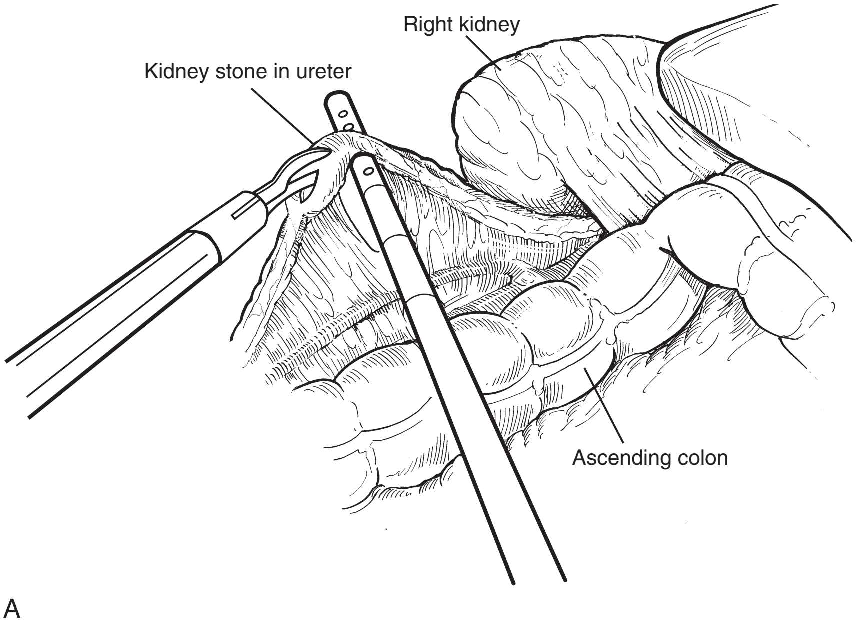


FIGURE 17–4. If a stent or catheter cannot be passed above the level of the stone, an open-ended catheter should be advanced to the stone. A Council Tip bladder catheter can be placed over the open-ended catheter and inflated in the bladder. Using a "Y" adapter attached to the bladder catheter, urine drainage can be achieved and a wire manipulated through the open-ended catheter once the stone has been removed.



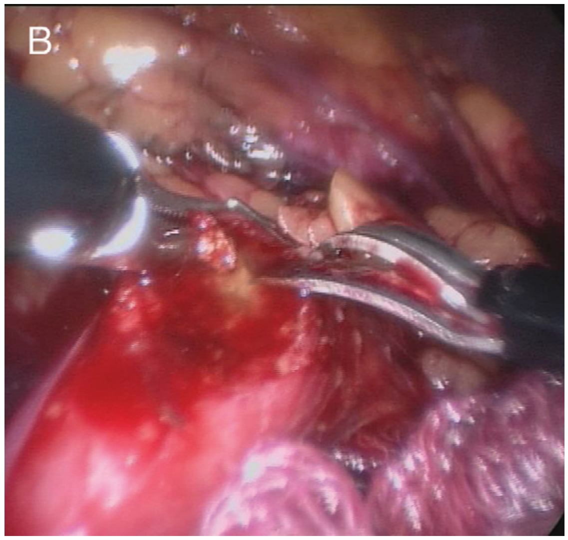


FIGURE 17–5. *A,* Once the stone is located in the ureter, the ureter is opened with laparoscopic scissors or a laparoscopic cold knife. *B,* The stone can usually be felt with the tip of the scissors.

Transperitoneal Approach

Medially reflect the colon over the stone, and expose the retroperitoneum. Using sharp and blunt dissection, expose the ureter while passing over the psoas muscle or crossing the iliac vessels. Isolate the ureter, and pass a vessel loop underneath it to tent it up and to prevent the stone from migrating. Alternatively, use a Babcock forceps to grasp the dilated ureter proximal to the uppermost calculus for the same reason. Usually, it is easy to identify the stone because its size causes the ureter to bulge adequately or because the graspers can palpate it. Using a cold knife, incise the ureter over the calculus beginning about 0.5 cm proximal to the stone (Fig. 17–5). Loosen the stone and lever it out with the help of a dissector (Fig. 17–6). Once the stone is extracted, use spoon forceps to remove the stone from the abdomen. Place stones that are too large to pass through the 10-mm port in a small laparoscopy bag and remove them at the conclusion of the procedure. Flush the ureter with saline to remove any stone fragments and to confirm patency. Leave the ureterotomy open if it is smaller than 1 cm or close it with interrupted 3-0 absorbable sutures (Fig. 17–7). Usually, if a stent is not already in place, do place a double-J stent either with the help of flexible cystoscopy or with laparoscopic manipulation introducing the double-J through one of the laparoscopic ports. A stent is not always needed unless the ureteral incision is not sutured. Always leave a drain in the retroperitoneal space. Following fluoroscopy to confirm a stone-free status and proper stent placement, remove ports after CO_2 deflation.

Retroperitoneal Approach

After placing the trocars, the steps are the same as in the transperitoneal approach. Postoperative management is also the same.

POSTOPERATIVE MANAGEMENT

The patient resumes oral food intake on postoperative day 1, the Foley catheter is removed on postoperative day 2, and the drain is removed the same afternoon if the output is less than 30 mL. The stent is removed 4 weeks postoperatively, and an intravenous pyelogram is performed 6 weeks later. Further follow-up varies.

COMPLICATIONS

Complications were minor and mainly constituted short-term postoperative fever, ileus, deep venous thrombosis, incisional hernias, subcutaneous emphysema, and subcutaneous hematomas. Urinary leak was commonly seen,[7] but eventually tapered off. Harewood and associates[10] reported a urinary leak in 55.5%, but this was of 3-day duration only. Keeley and colleagues[11] and Skrepetis and associates[8] reported longer leakages of 12 and 10 days, respectively, which were treated conservatively. They were attributed to the fact that no internal stents were placed. A urinoma requiring drainage was reported by Micali and colleagues,[12] but in this case no drain was placed. Bowel and vascular injuries and injuries of neighboring organs are always a risk during laparoscopic surgery, although they were not reported in these series of procedures.

There are no long-term results concerning the incidence of ureteral stricture postoperatively. In most cases, the ureterotomy was made with a cold knife because the use of scissors to cut a frequently thick ureter can be tedious. Some authors used the diathermy hook[10] or a neodymium:YAG laser,[3] but no data are reported about the incidence of postoperative ureteral stenosis in this setting.

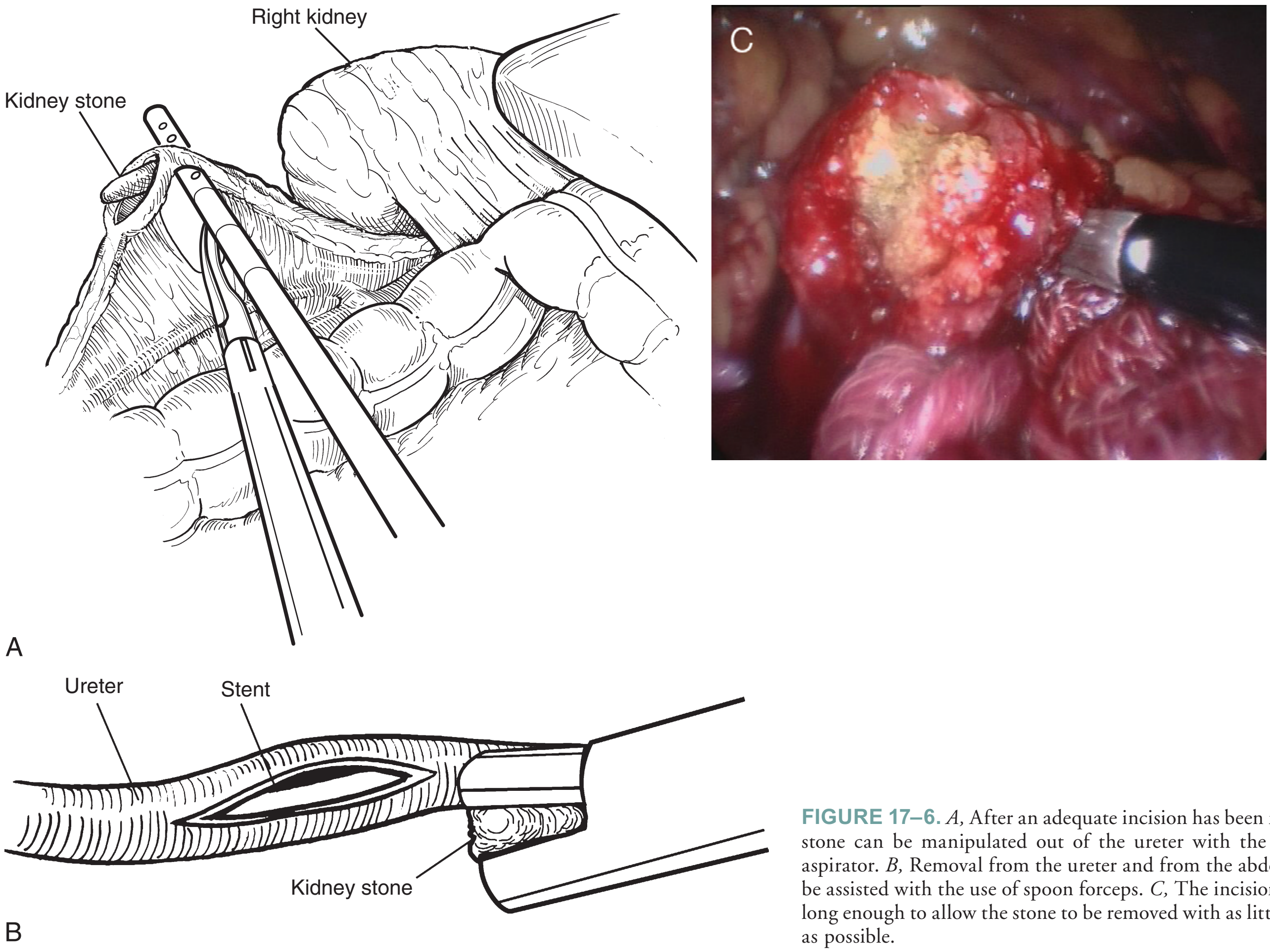


FIGURE 17–6. *A,* After an adequate incision has been made, the stone can be manipulated out of the ureter with the irrigator-aspirator. *B,* Removal from the ureter and from the abdomen can be assisted with the use of spoon forceps. *C,* The incision must be long enough to allow the stone to be removed with as little trauma as possible.

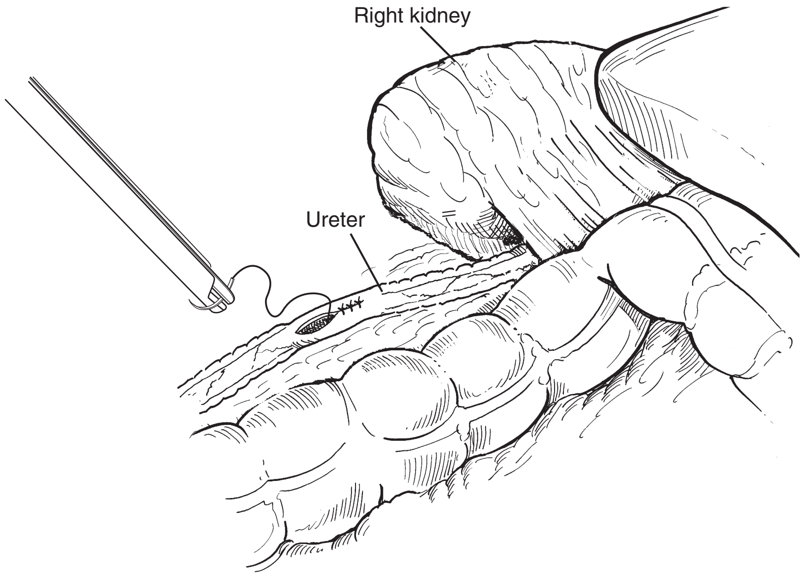


FIGURE 17–7. Once the stone is removed, a stent can be advanced into the kidney if not already present, and the ureteral defect is closed using free-handed suturing or with the help of the EndoStitch device.

RESULTS

Large series of laparoscopic ureterolithotomies do not exist. This reflects the fact that open stone surgery is rarely indicated, due to the high success rates of ESWL and endoscopic ureterolithotripsy.

The only comparative study of laparoscopic versus open ureterolithotomy, by Skrepetis and colleagues,[8] confirmed the advantages of less analgesia requirements, shorter hospital stay, and faster recovery of laparoscopy over open surgery. In all series, the stones were removed and no other procedure was necessary.

TABLE 17–1. LAPAROSCOPIC URETEROLITHOTOMY SERIES

Study	No. of Patients	Approach	Stone Size Range (mm)	Suture Placed	Stent Placed	Mean Operative Time (min)	Conversion Rate (%)	Mean Hospital Stay (days)	Success Rate (%)
Rabou et al[1]	1	Trans	—	No	+	—	—	1	100
Bellman and Smith[5]	2	Trans	10–11	No	+	—	—	—	100
Gaur et al[4]	8	Retro	12–20	No	+, –	40	37.5	1	62.5
Harewood et al[10]	9	Trans and retro	5–28	Yes	+, –	158	—	5.2	100
Fahlenkamp et al[3]	2	Trans	11–18	Yes	+	—	—	2	100
Micali et al[12]	6	Trans	10–18	Yes	+	222	20	3.3	83.3
Keeley et al[11]	14	Trans	18–40	Yes/no	+, –	105	—	5.6	100
Skrepetis et al[8]	18	Trans	12–31	Yes	+, –	130	—	3.2	100
Demirci et al[7]	21	Retro	—	Yes	+/–	105	—	6	89
Vallee et al[13]	18	Trans and retro	8–25	Yes	+/–	80	—	3.8	100
Feyaerts et al[6]	24	Trans and retro	7–33	Yes/no	+, –	111	—	3.8	100

Retro, retroperitoneal; Trans, transperitoneal.

Gaur and associates[4] had to convert to open surgery in three of eight patients because stone extraction was not possible. They attributed these failures to inadequate instrumentation. This study was one of the first to be reported; since then, advances in instrumentation have made the failure of stone removal rare. However, keep in mind that these stones are usually impacted and adhered to the ureteral wall, which commonly is thick and inflamed. In the largest series (24 patients) by Feyaerts and colleagues,[6] only one laparoscopic procedure failed due to accidental push-back of the stone to the kidney, whereas Demirci and associates[7] had a higher failure rate of 11%. However, most studies have high success rates, almost always approaching 100% (Table 17–1).

SUMMARY

Laparoscopic ureterolithotomy, although rarely performed, is feasible and presents with excellent results.

Tips and Tricks

- After identifying the stone, always pass a vessel loop underneath the ureter and tent it up in order to prevent the stone from migrating. Alternatively, use a laparoscopic Babcock to grasp the dilated ureter proximal to the uppermost calculus for the same reason.
- Preoperatively place a ureteral stent to help locate the ureter. If it is not possible to bypass the stone, which is often impacted, leave a guidewire at the tip of the stone with the intention to facilitate subsequent double-J stent placement after ureterotomy and stone extraction.

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CHAPTER 18

Laparoscopic Ureteral Reimplantation and Boari Flap

Koon Ho Rha

In the past decade, laparoscopy has been successfully used for both the obliterative and reconstructive management of urologic disease. We have seen not only an advance in the technology available to perform these procedures but also an effort on the part of laparoscopic urologists to refine their techniques to allow them to perform more complicated procedures.

INDICATIONS AND CONTRAINDICATIONS

There are various indications for ureteral reimplantation in adults. For adults with injury or obstruction affecting the distal 3 to 4 cm of the ureter, such as stricture, penetrating trauma, or intraoperative injury, perform a ureteral reimplantation with a psoas hitch or Boari flap. Perform direct ureteral reimplantation if a tension-free anastomosis is possible; otherwise, use a psoas hitch or Boari flap. Perform a direct, nontunneled anastomosis if postoperative reflux is not an issue; otherwise, create a submucosal tunnel. Use a double-J stent postoperatively if desired, and place drains.

The psoas hitch is an effective means to bridge a defect of the lower third of the ureter. Indications include distal ureteral injury, ureteral fistulas secondary to pelvic surgery, segmental resection of a distal ureteral tumor, and failed ureteral reimplantation.[1] Ureteral defects proximal to the pelvic brim usually require more than a simple psoas hitch alone. A psoas hitch can provide an additional 5 cm of length compared with ureteral reimplantation alone. Its advantages over a Boari flap include simplicity, improved vascularity, ease of endoscopic surveillance, and minimal voiding difficulties.

Mid ureteral defects present a particular surgical challenge because this area has a tenuous blood supply and there are potential problems achieving a tension-free repair. When the diseased segment is too long or ureteral mobility too limited to perform a primary ureteral reimplantation, a Boari flap may be a useful alternative. A Boari flap can be constructed to comfortably bridge a 10- to 15-cm defect, and spiraled bladder flaps can reach to the renal pelvis in some circumstances. As with a psoas hitch, preoperatively completely visualize the ureter and evaluate bladder function. Preoperatively address bladder outlet obstruction and neurogenic dysfunction, and realize that a small bladder capacity predicts difficulty.

Although the ureteral reimplantation, psoas hitch, and Boari flap have conventionally been performed by open surgery, the advantages of the laparoscopic technique have rapidly come into the limelight. Shorter hospital stay, rapid recovery, less postoperative pain, and better cosmesis are the main advantages of laparoscopic surgery. The success of every laparoscopic procedure depends on proper patient selection and the surgeon's skill and confidence with laparoscopy.

Improvements in the skills of laparoscopic urologists and the advent of instruments to facilitate suturing (e.g., Lapra-Ty [Ethicon, Cincinnati, OH], clips to replace intracorporeal knotting, and advances in staple and clip technology) have facilitated a renewed interest in laparoscopic reconstructive surgery of the lower urinary tract. The latest development in reconstructive laparoscopic urology has been the advent of the semiautomatic suturing device, the EndoStitch (Auto Suture, U.S. Surgical, Norwalk, CT). With this device, the needle and suture can be rapidly passed through both edges of the tissue without the surgeon needing to physically grasp the needle. This greatly speeds up the sewing process; indeed, in one clinical series of pyeloplasty, Moore and associates[2] estimated that the introduction of the EndoStitch into their procedures reduced the operating room time by 2.1 hours. At present, almost all types of urologic open reconstructive procedures have been accomplished laparoscopically: urinary diversion, bladder reconstruction, ureteral reimplantation, and urethrovesical anastomosis following radical prostatectomy. This chapter reviews the development of ureteral reimplantation and Boari flap.

PATIENT PREOPERATIVE EVALUATION AND PREPARATION

Preoperatively, measure the length of defective ureter on antegrade and retrograde radiographs. Note that the length usually is over or underestimated; it is rarely accurate. After thoroughly reviewing all options, including psoas hitch and other endoscopic methods, if the laparoscopic Boari flap is selected, evaluate the bladder volume carefully. Review previous radiation or previous injury to the bladder. Carefully review previous pelvic surgeries to reveal additional information.

OPERATING ROOM CONFIGURATION AND PATIENT POSITIONING

Patient positioning is the same for all of the ureteral reimplantation procedures. As with other laparoscopic procedures, the operating room is configured so that the entire team can view the procedure on the monitor. Position the patient in a supine position, and carefully secure the patient to the table so that an

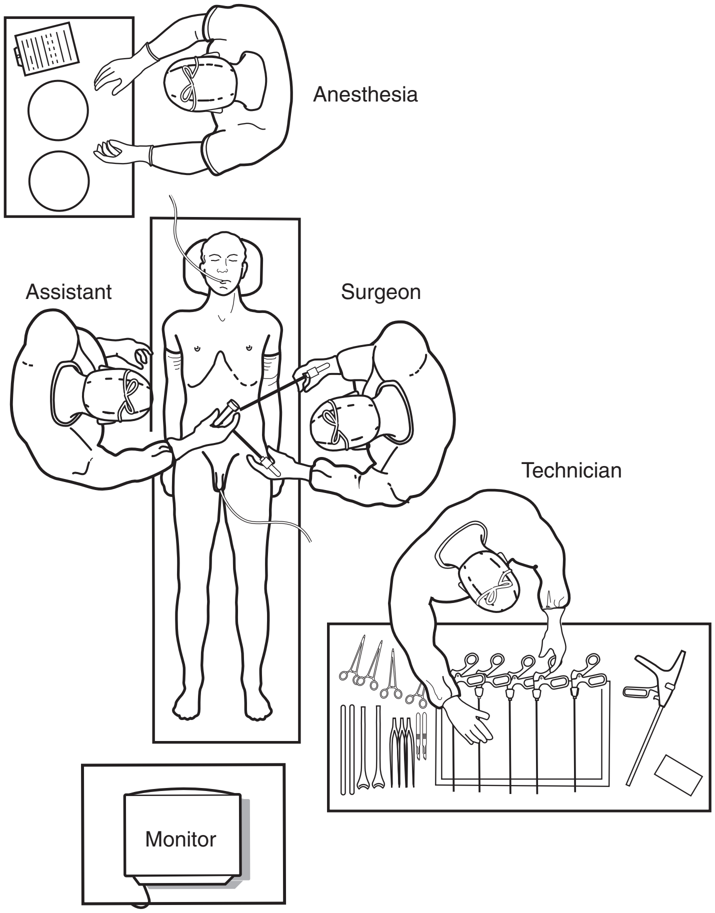


FIGURE 18–1. The operating room is configured so that the entire staff can view the procedure. The patient is positioned supine with the arms tucked. Several bands of tape are used to secure the patient at the shoulders, hips, and legs. The patient needs to be carefully secured to the table to allow being placed in the head-down position to allow bowel to fall away from the pelvis, improving exposure to the bladder.

exaggerated head-down position can be used to move the bowel contents away from the bladder (Fig. 18–1).

Assess the length and location of the ureteral stricture by preoperative antegrade and retrograde studies. With the patient under general anesthesia, prepare the abdomen and genitalia in the operative field. Place an orogastric tube and have the Foley catheter within the field to allow access during the procedure. Achieve pneumoperitoneum using a Veress needle.

TROCAR PLACEMENT

Insert the initial trocar at the umbilicus using Veress access with a 10/12-mm supraumbilical port for the camera. Place two additional 5-mm working trocars under direct vision at the level of the iliac crest along the lateral edge of the rectus muscle, triangulating these with the camera port. These ports are used for the initial colonic dissection (Fig. 18–2). In female patients, make the initial dissection in the peritoneal fold between the bladder and uterus to gain access to the ureters in the region of the trigone. In male patients, the ureter can be seen as it crosses posterior to the vas deferens. Create a peritoneal window, and free and elevate the ureter inferior to the vas deferens. Mobilize each ureter once it can be elevated onto the base of the bladder sufficiently for placement in a detrusor tunnel. Dissect the ureter up to the juxtavesical region and transect it after ligation of the distal end. Then spatulate the ureter; this is usually easily performed because the proximal ureter is dilated and accommodates the scissors without difficulty.

Anteriorly mobilize the bladder to develop the prevesical space. Similarly, posteriorly dissect the bladder to maximize mobility before opening it. Choose the site of the ureteral reimplantation so that it is as inferior and medial as possible. Fill the bladder with 150 to 200 mL of saline. Using the scissors, hook, and needle-tip electrode, incise the detrusor about 3 cm, allowing the mucosa to bulge out between the muscularis edges. Be careful not to enter the mucosa before being ready to make the anastomosis because the bladder will rapidly decompress, making further dissection of the muscularis difficult.

Open the mucosa in the most distal portion of the incision. Take the first stitch through the apex of the spatulated ureter and the proximal end of the hole in the mucosa using a 3-0 absorbable suture on a round-body needle following an intracorporeal suturing technique. Make eight interrupted sutures. This fixes the ureter in the detrusor groove created earlier. Before taking the last few stitches, place the double-J stent. Then close the detrusor with three interrupted sutures of 3-0 polyglycolic acid to make the submucosal tunnel.

Laparoscopic Ureteral Reimplantation

McDougall and colleagues[3] described ureteral reimplantation into the bladder in 1995. They used the Lich-Gregoir technique. They used intracorporeal suturing technique to perform the ureteral-vesical anastomosis over which the detrusor tunnel was closed, by 3-0 polyglactin suture in four pigs and with tacking staples in three pigs.

Ehrlich and associates[4] successfully treated vesicoureteral reflux in two children using the laparoscopic technique. The operative time was 2 to 3 hours. In both cases, they performed an extravesical and Lich-Gregoir repair. There were no complications. Two-month follow-up showed no reflux or hydronephrosis. Reddy and Evans[5] first performed a laparoscopic ureteroneocystostomy on a 74-year-old patient who presented with hydronephrosis after transurethral resection of the prostate and cystoscopy revealed an obliterated left ureteral orifice. They laparoscopically transected the dilated ureter and advanced the nephroureteral catheter into the bladder through a neocystotomy. The ureteroneocystostomy was completed with six 3-0 polyglactin interrupted sutures. The operative time was 4.5 hours, and at 3 weeks postoperatively the ureter was patent with no extravasation.

Yohannes and associates[6] described the technique in detail, reporting their experience in a case of lower-ureteral stricture. They used an EndoStitch device to assist with the suturing. Yohannes and colleagues[7] later described robot-assisted laparoscopic reimplantation, but it was a simple ureterovesical refluxing anastomosis.

The main indication for ureteroneocystostomy in children is vesicoureteral reflux, and the ureteral dissection in the perivesical region is easy because the planes are virgin and untouched. In the adults, however, one indication for ureteroneocystostomy is iatrogenic injury of the ureter, and posthysterectomy injury is a common indication. Consequently, the dissection of the distal ureter can be extremely difficult, and the degree of mobilization of the ureter may be limited. In addition, because the level of the ureteral injury is not certain, it may be necessary to tackle higher levels of injury, and it may be necessary to manage with lesser lengths of ureter. This, in turn, means that the surgeon must be ready for more difficult surgical steps such as the psoas hitch and full mobilization of the ureter. It is imperative in the child that the detrusorrhaphy achieve a secure antireflux mechanism, whereas in the adult, the antireflux repair generally is not considered important. This is probably because the procedure becomes more complicated and because of fear that the detrusorrhaphy will cause an element of vesicoureteral obstruction.

Psoas Hitch

If the anastomosis is on tension, a psoas hitch can be performed. The psoas muscle is already exposed by the earlier dissection of the ureter. Use polypropylene 2-0 on a round-body needle. Make the first pass into the bladder muscle lateral to the neoureterocystostomy site. Then pass the needle into the psoas muscle, taking care not to injure any other structure. Make a knot with help from the assistant, who uses the fourth port, to prevent the knot from slipping. Take a second suture lateral to the first that supports the hitch. Perform the psoas hitch after the ureterovesical anastomosis, based on the open surgical technique described by Hendren.[8]

After the repair is complete, remove instruments and trocars after checking for bleeding and visceral injury. Close the fascial defects and skin of each port with absorbable sutures. Leave a bladder catheter in place for several days.

Laparoscopic Boari Flap

The Boari flap is a viable alternative for ureteral reconstruction when long defects of the mid to lower ureter must be bridged to the bladder. In 1894, Casati and Boari[9] first described this technique in a canine model, and in 1947 it was first applied in humans.[10] Fergany and associates[11] described a laparoscopic Boari flap in a porcine model. Fugita and colleagues[12] described three cases of the laparoscopic Boari flap technique for lower-ureteral stricture. Excellent outcomes were achieved in their patients with regard to symptomatic relief, radiologic results, and renal function. In 2005, Castillo and associates[13] also described eight cases of the laparoscopic Boari flap and expressed that the laparoscopic Boari flap was a feasible alternative surgical technique in patients with long distal ureteral strictures.

PROCEDURE

With the patient under general anesthesia, prepare the abdomen and genitalia into the operative field. Pass a Foley catheter, and place the patient supine. Use a Veress needle to achieve pneumoperitoneum. Place two 10/12-mm ports, including one through the umbilical incision for the camera and one at McBurney's point under direct vision. Place a 5-mm port in the lateral edge of the rectus muscle at the level of the umbilicus under direct vision.

Reflect the colon medially by incising the line of Toldt from the liver on the right and spleen on the left sides to the medial umbilical ligament. At this point, extend the incision medial to the umbilical ligament on the anterior abdominal wall. The ureter is then visible above the level of iliac vessels and freed as distally as possible. It is always important to preserve the periureteral tissue during its dissection to avoid ureteral devascularization. Transect normal ureter above the stricture area and spatulate it posteriorly on the normal ureter proximal end (Fig. 18–3).

Fill the bladder with 150 to 200 mL of saline, and incise the overlying anterior and contralateral peritoneum. Ligate and transect the urachus with clips. With blunt dissection, free the

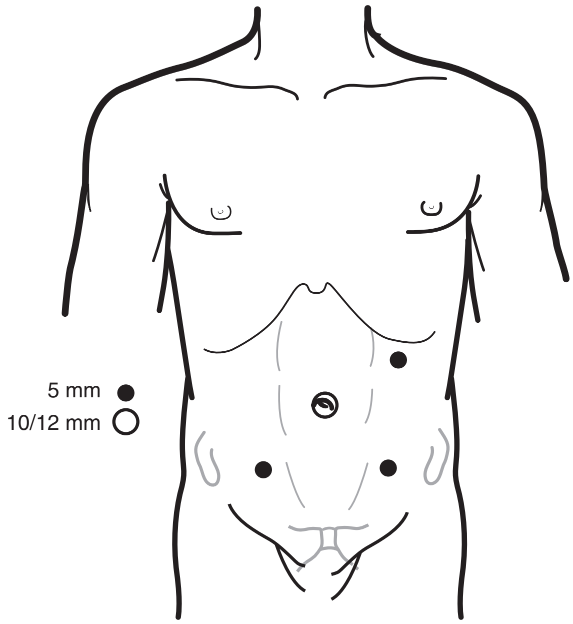


FIGURE 18–2. After insufflation with the Veress needle, the trocars are placed. A 10/12-mm trocar is placed at the umbilicus for the camera. Two additional trocars are placed at the level of the anterior superior iliac crest lateral to the rectus muscles.

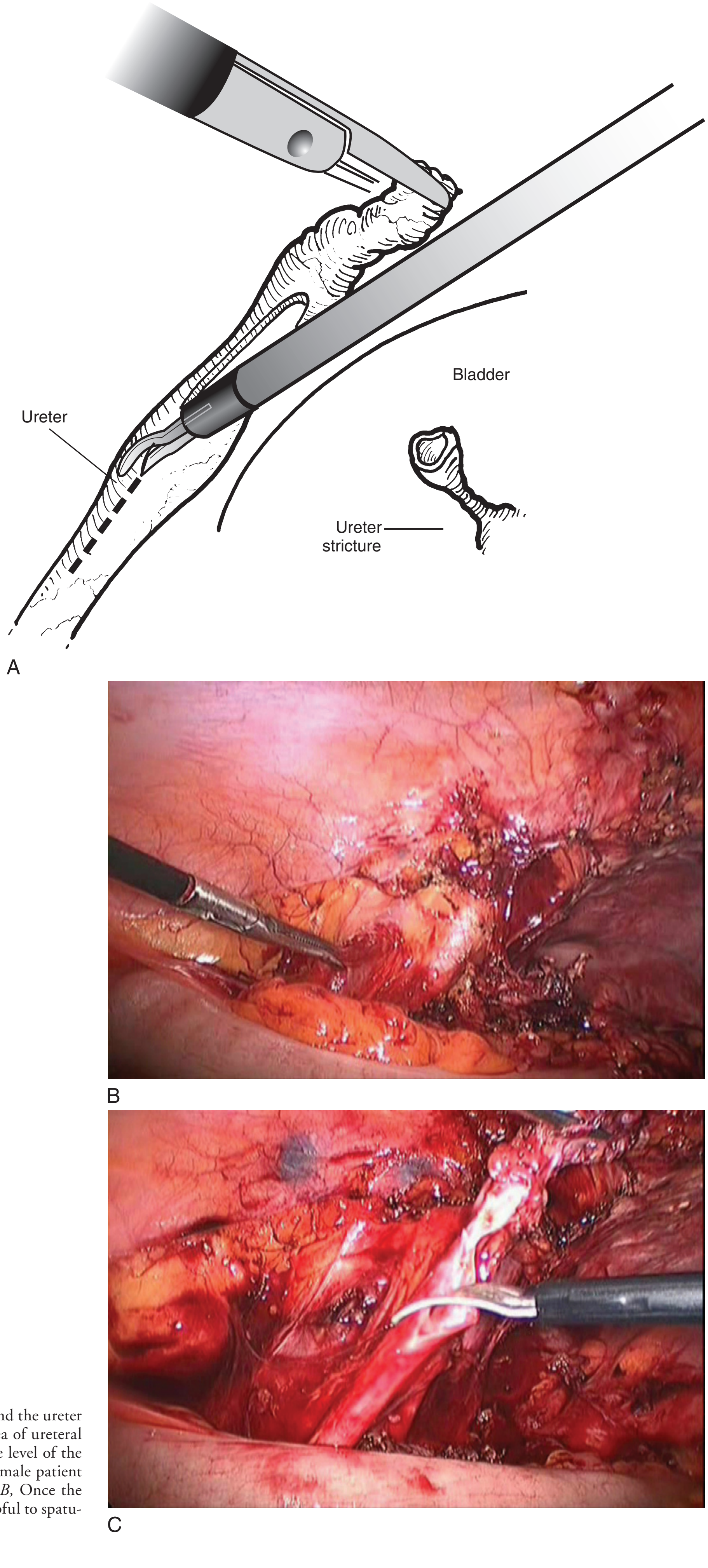
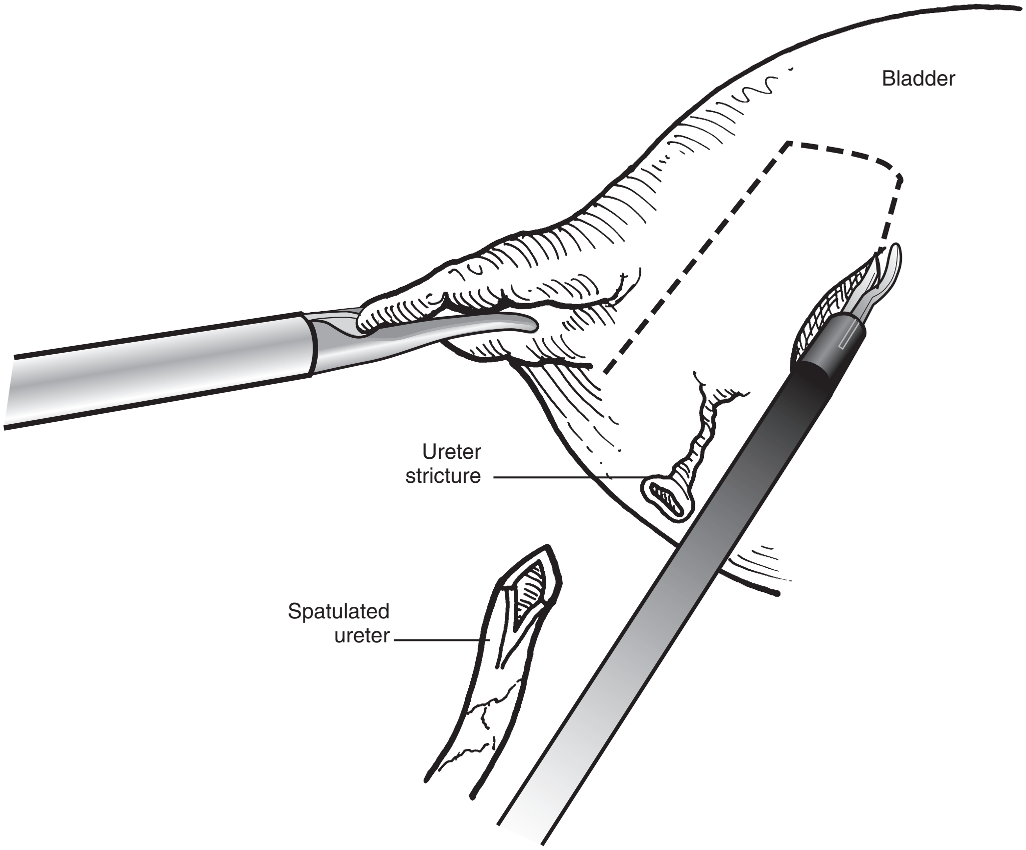


FIGURE 18–3. *A,* A peritoneal window is created and the ureter identified. It can be difficult to locate the precise area of ureteral stricture. An opened catheter can be advanced to the level of the stricture during the case with a flexible scope in the male patient or at the start of the procedure in a female patient. *B,* Once the stricture is identified, the ureter is incised. *C,* It is helpful to spatulate the ureter before complete transection.



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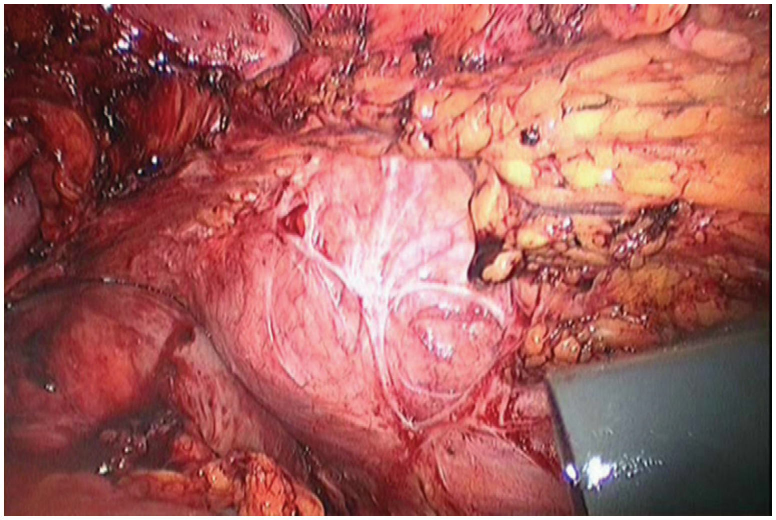
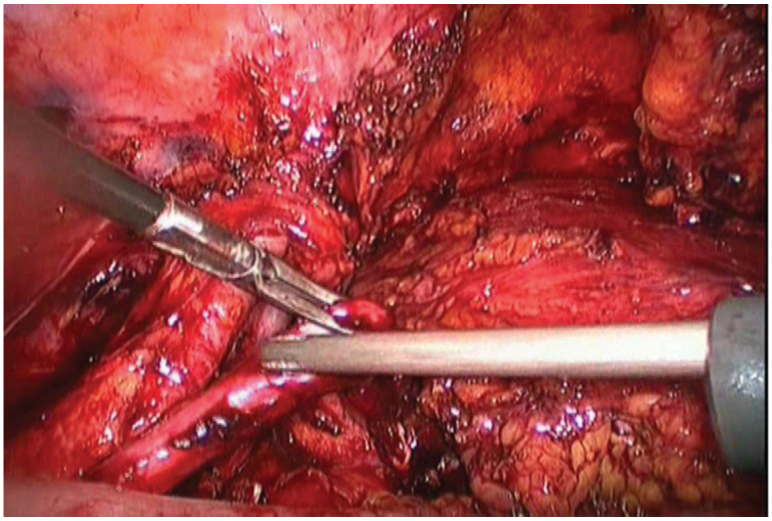


B

FIGURE 18–4. *A,* Using a bladder catheter, the bladder is distended and peritoneum opened from the lateral, anterior, and posterior aspects. *B,* The surface is cleared and the bladder mobilized.



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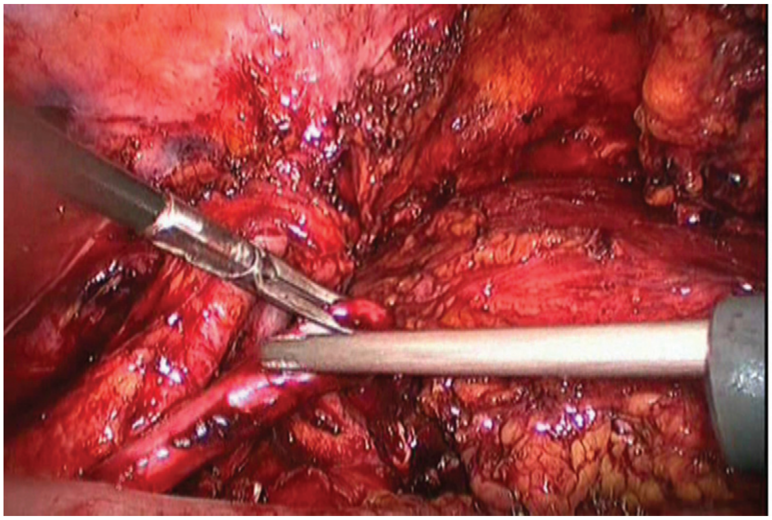

D

FIGURE 18–4, cont'd. *C,* The anticipated area of insertion is identified with the bladder distended. *D,* The bladder flap is created, unfolding toward the incised ureter.

bladder anteriorly, into the Retzius space. Clip or staple the superior and middle vesical arteries on the contralateral side (EndoGIA stapler [U.S. Surgical]), and divide them if necessary to achieve additional bladder mobility.

Create an anterior bladder flap with an apex of approximately 2 cm and a base of 4 cm, beginning about 2 cm distal from the bladder neck and extending to the ipsilateral posterior dome, as described by Fugita and colleagues[12] (Fig. 18–4). Bladder flap size varies according to the length of the ureteral defect to be gapped. Fix the bladder dome to the ipsilateral psoas with 2-0 polyglactin suture. Anastomose the ureter to the flap using an interrupted 4-0 polyglactin suture, as described by Fugita and associates,[12] and tie the suture intracorporeally (Fig. 18–5). After completion of the posterior anastomosis, pass the double-J stent up the ureter and renal pelvis under laparoscopic and fluoroscopic guidance by first advancing a Bentson guidewire through the most inferior trocar site. Advance the stent over the wire, and subsequently remove the wire (Fig. 18–6). Place the double-J stent in the bladder, and use an interrupted 4-0 polyglactin suture to close the anterior flap. Close the cystotomy with running 3-0 polyglactin to form a watertight seal (Fig. 18–7). Confirm the integrity of the closure by filling the bladder with 250 to 300 mL of saline and reinforcing it with interrupted 3-0 polyglactin suture if any irrigant leaks (Fig. 18–8). Place a closed suction drain through a lower abdominal trocar site and place it behind the anastomosis.

After the repair is complete, remove instruments and trocars after checking for bleeding and visceral injury. Close the fascial defects and skin of each port with absorbable sutures. Remove a bladder Foley catheter and drain on postoperative day 7 if cystography shows no urinary leakage. The stent remains for 4 weeks, and the patient resumes normal activity as tolerated.

POSTOPERATIVE MANAGEMENT

After surgery, closely monitor the drains and Foley catheter for any disruption or obstruction of the anastomotic sites. The ureteral catheter is left in place for at least 1 week and removed judiciously.

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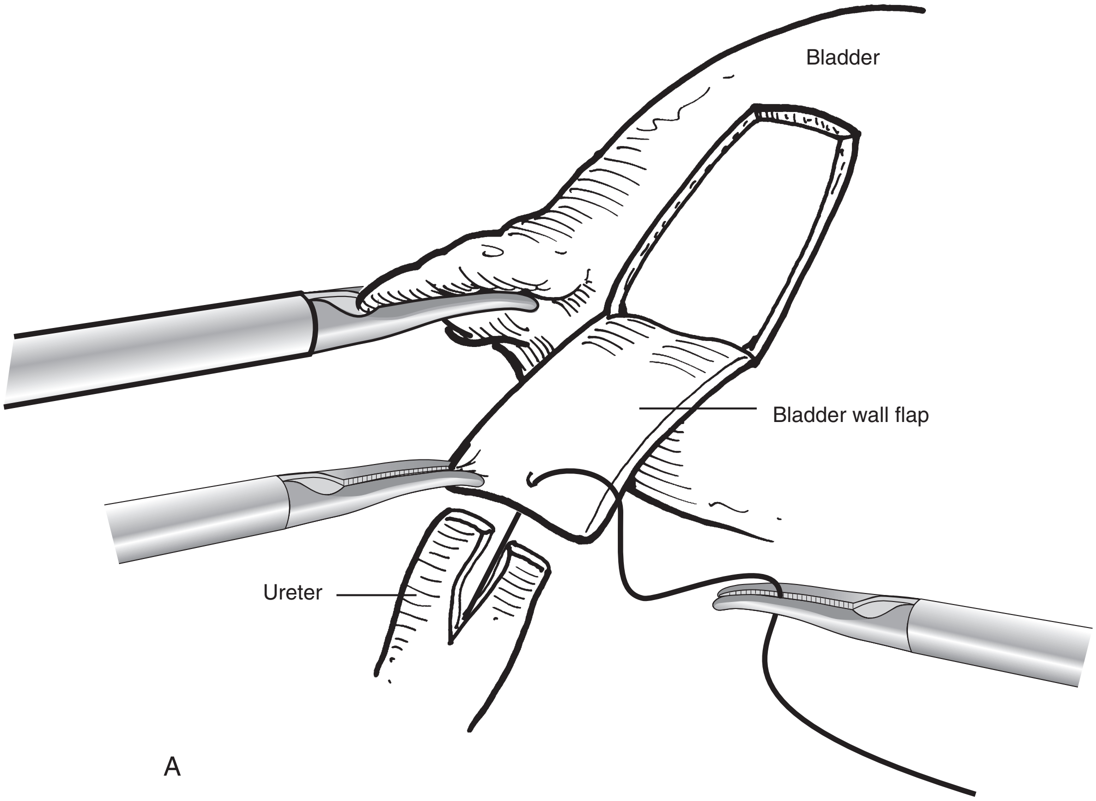

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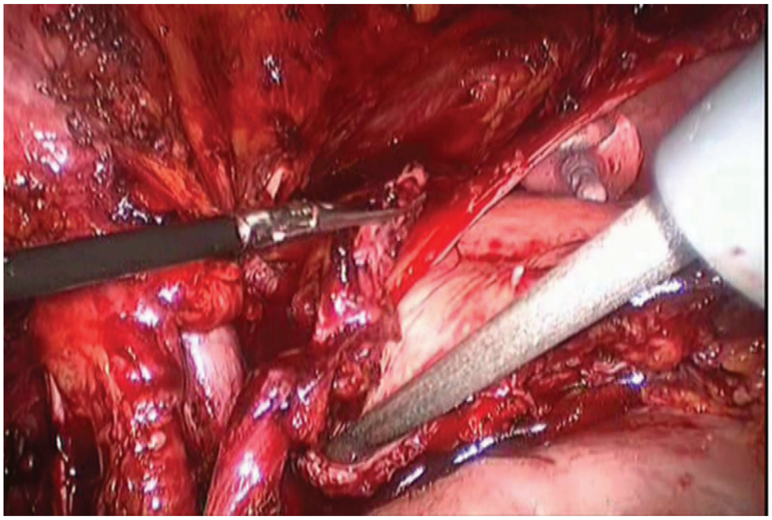
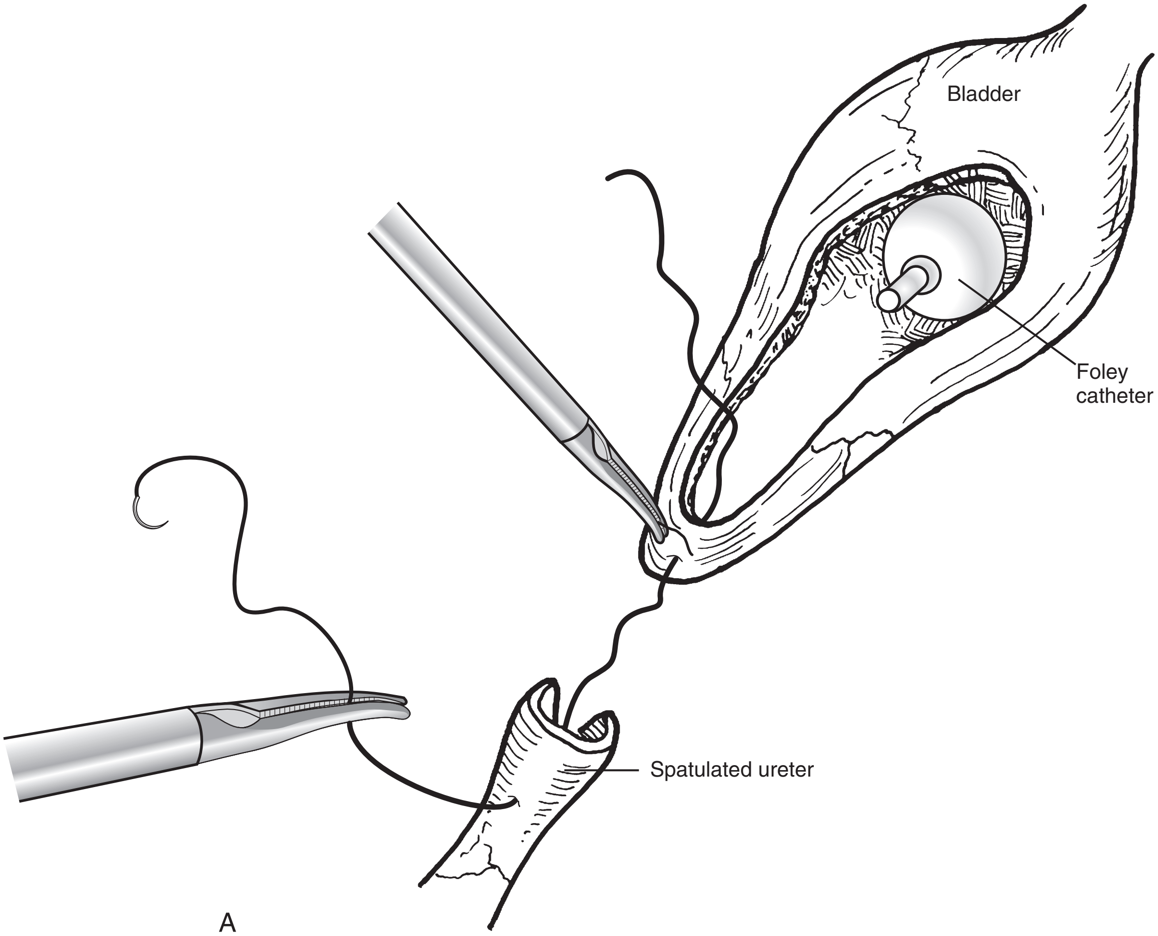


B

FIGURE 18–5. *A,* A 3-0 Vicryl suture is placed in the end of the spatulated ureter. *B,* The bladder flap is pulled down to ensure a tension-free anastomosis, and the bladder entry site chosen in an inferior and medial location. The apex suture is placed in the bladder.



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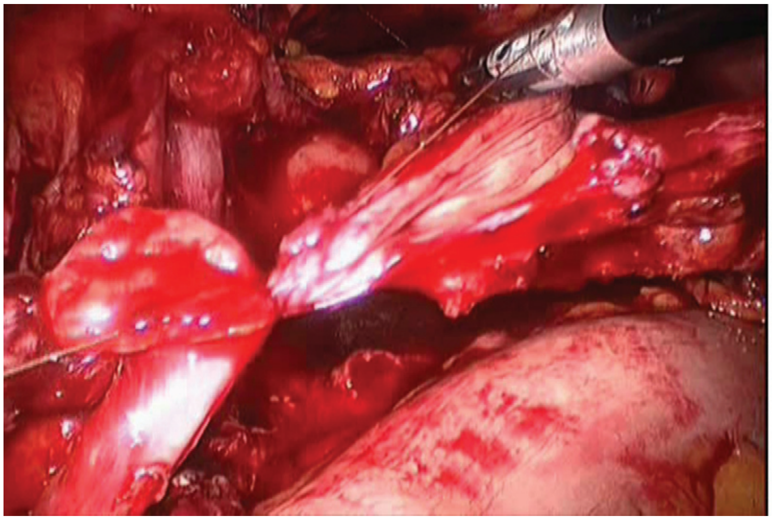

B

FIGURE 18–6. *A,* The bladder is pulled down while the suture is tied. *B,* The EndoStitch (U.S. Surgical) can be used to help with suturing, or intracorporeal techniques can be used according to the skill of the surgeon.

Continued

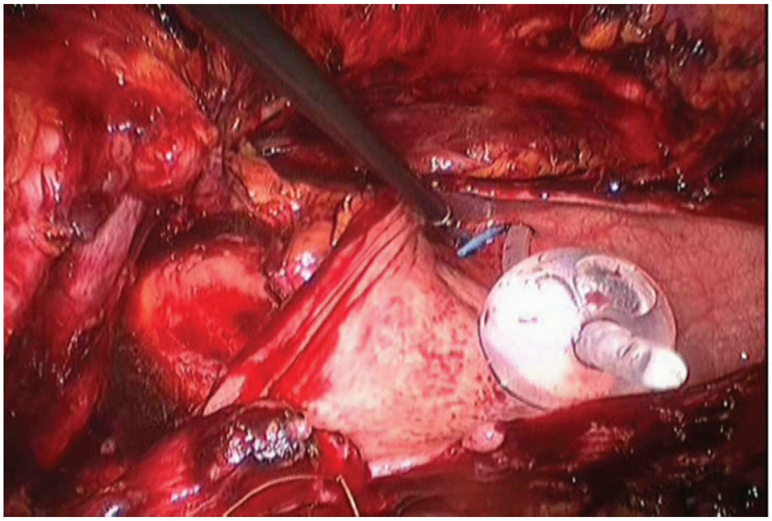

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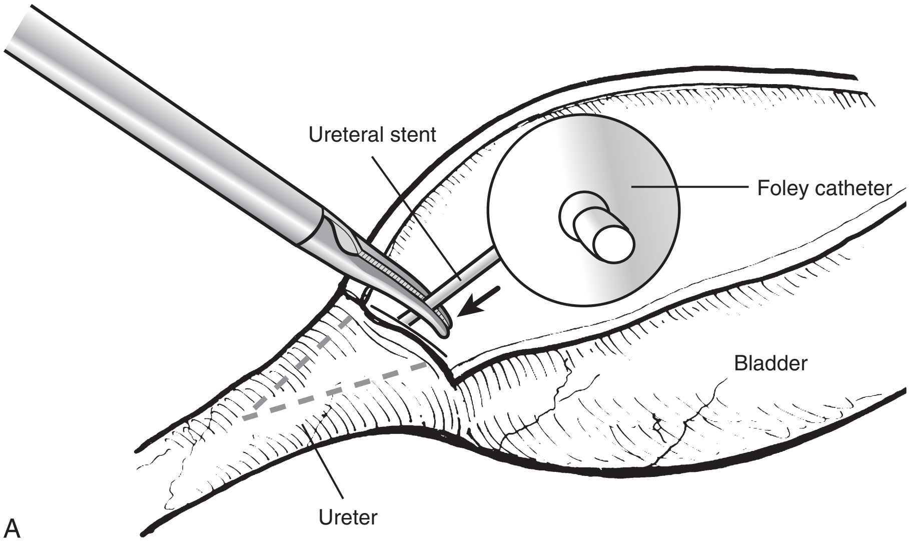
FIGURE 18–6, cont'd. *C,* A ureteral catheter is introduced into the bladder.



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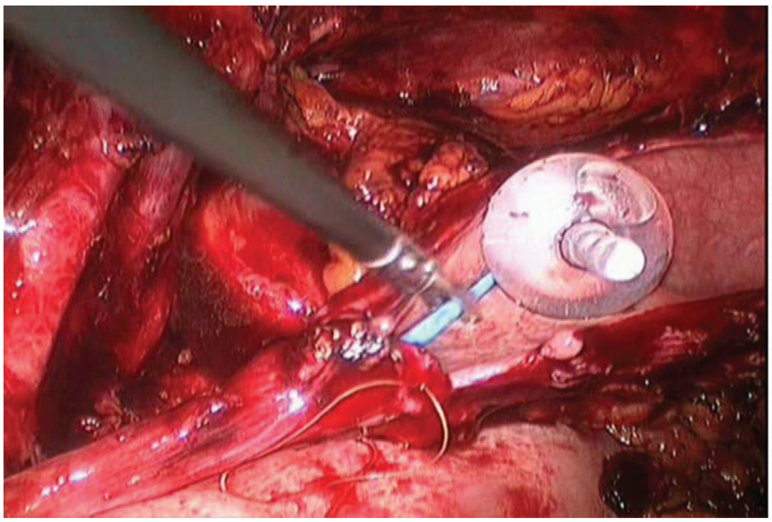
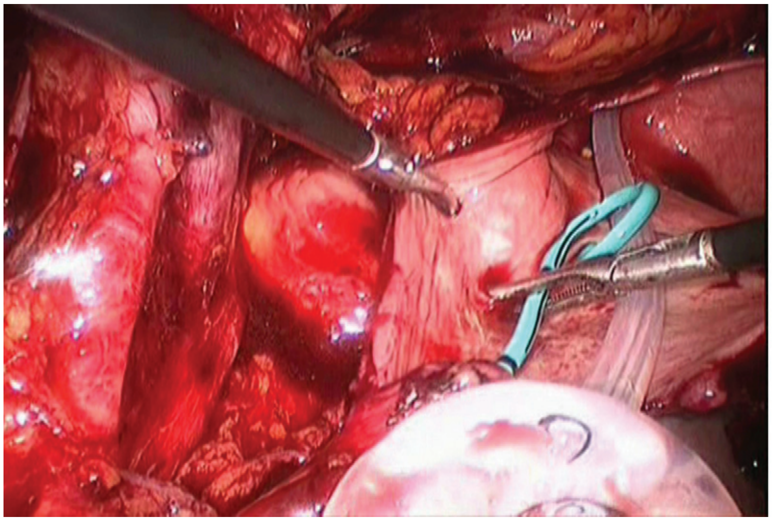


B

FIGURE 18–7. *A,* The ureteral catheter is pulled into the bladder and advanced up the ureter over a wire. *B,* A grasper is used to gently advance the ureteral stent into position.



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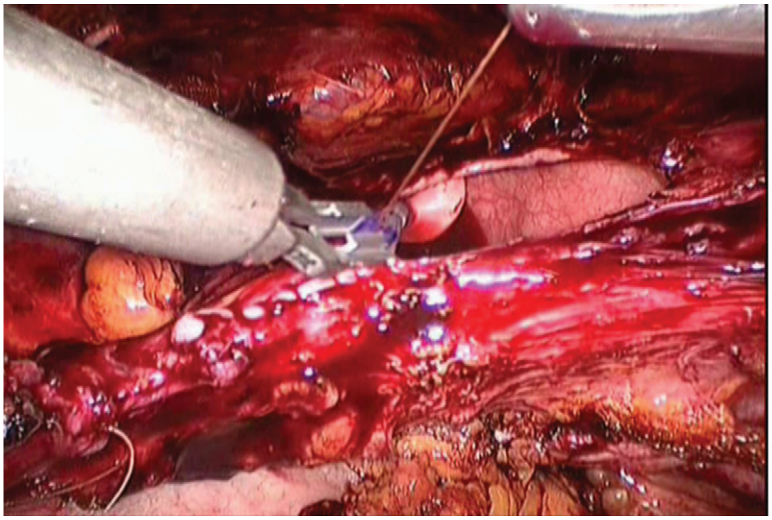
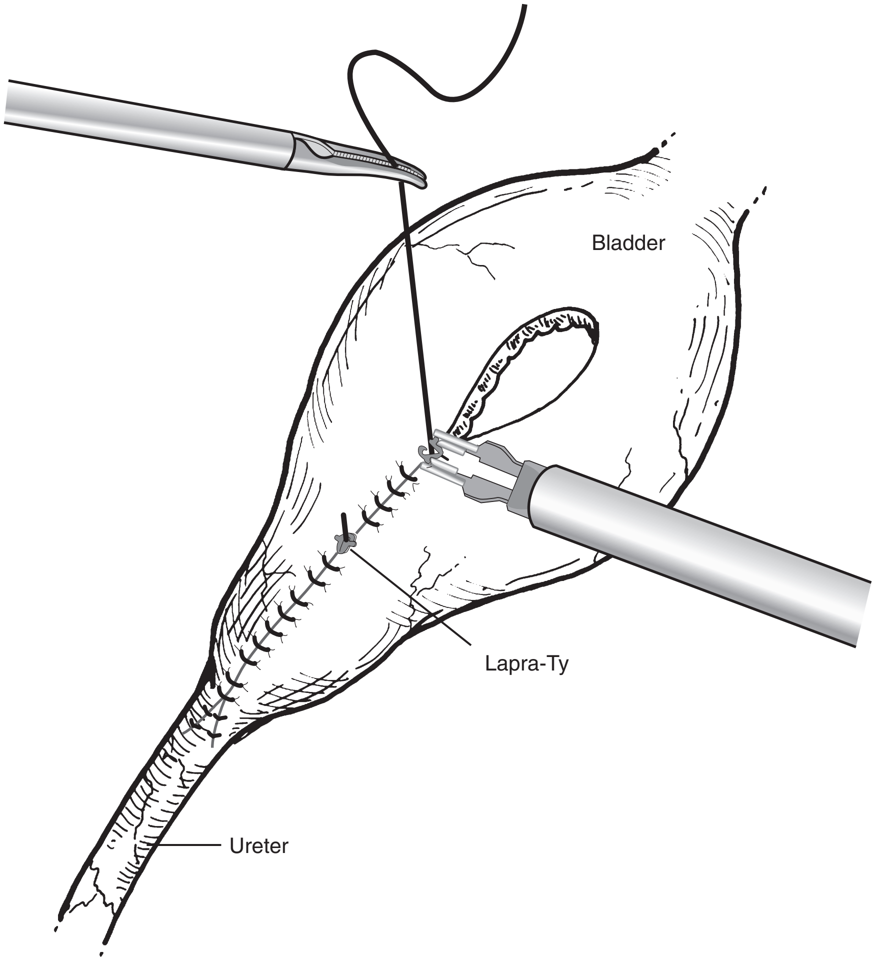


D

FIGURE 18–7, cont'd. *C,* A long stent is chosen so that it can be advanced to the kidney and also be in a dependent portion of the bladder. *D,* Interrupted sutures are used to secure the ureter, and running sutures are used to close the bladder defect.



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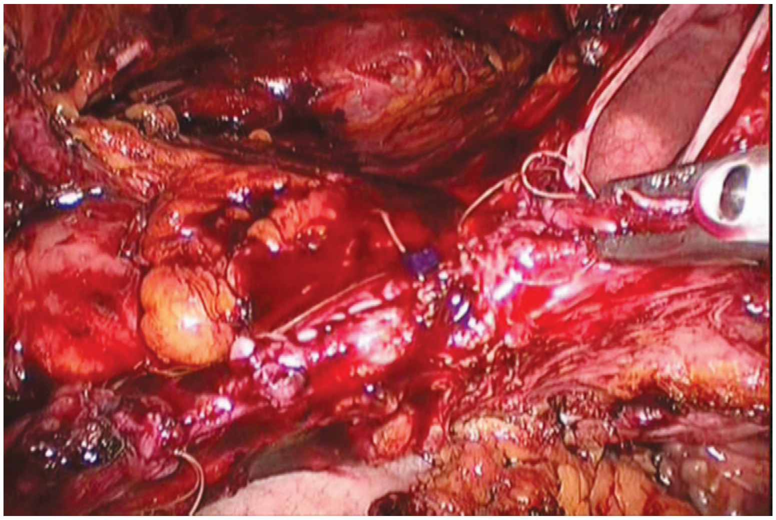
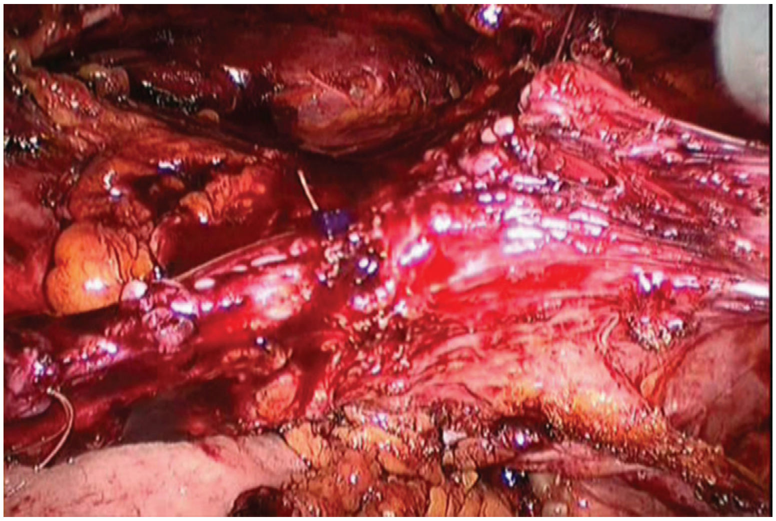


B

FIGURE 18–8. *A,* The Lapra-Ty (Ethicon) is useful when closing a long suture line, because shorter sutures are usually easier to work with during laparoscopy. *B,* The Lapra-Ty is being applied to the first suture closing the bladder.



C

FIGURE 18–8, cont'd. *C,* The anastomosis is complete, and the last tie can be substituted with a Lapra-Ty, making the suture line watertight.

Radiologically follow the patients every 3 to 6 months for any obstructions after repair.

COMPLICATIONS

Prolonged urinary drainage through the drain may occur. If the ureteral stent or catheter is well placed, the condition is usually temporary. Review the surgical repair and suturing of the flap, and confirm the position of the ureteral stent or catheter. Urinary obstruction after removal of stent may occur. Diuretic renogram is helpful in determining actual obstruction. If the obstruction is present, balloon dilation of ureteral narrowing may relieve the obstruction.

Urinary frequency and other voiding symptoms due to the reduced bladder capacity are common in the immediate postoperative period. Usually, the bladder capacity increases gradually and the frequency does not persist to the same degree.

SUMMARY

Laparoscopic ureteral reimplantation, psoas hitch, and Boari flap are feasible surgical techniques in patients with distal ureteral stricture or long mid and distal ureteral stricture. Medium-term follow-up demonstrates symptomatic renal function and radiographic outcomes similar to those of open technique. Advanced laparoscopic skills are definitely needed to perform this procedure. Currently and in the near future, this procedure will be widely performed with robot-assisted laparoscopy technique.[14]

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CHAPTER 19

Laparoscopic Adrenalectomy

Blake D. Hamilton

Since the initial report of laparoscopic adrenalectomy in 1992,[1] this procedure has become the gold standard for the removal of most adrenal pathology. Now there is little debate regarding the merits of this technique. Curiously, there has never been a prospective randomized study comparing open and laparoscopic adrenalectomy, yet in the published literature, there are more than 400 entries from around the world describing the surgical experience with laparoscopic adrenalectomy. At this point, the jury has weighed in so favorably on the side of laparoscopy that a randomized trial will likely never be done.[2–9]

Rather, discussion now centers on questions such as which laparoscopic approach is best? What about adrenal sparing with partial excision? How large is too large for a laparoscopic approach? Is this technique ever appropriate for malignant disease? In this chapter, I describe the current techniques for transperitoneal and retroperitoneal adrenalectomy. I also address the current indications for laparoscopic adrenalectomy and try to answer the above questions. What is clear is that laparoscopic adrenalectomy has become the standard for adrenal surgery. For additional perspective on this procedure, several excellent reviews have been published.[10–12]

INDICATIONS AND CONTRAINDICATIONS

Laparoscopic adrenalectomy is clearly preferred for benign adrenal tumors. These tumors can be classified as functional or nonfunctional (Table 19–1). A *nonfunctional* adrenal tumor generally manifests as an incidental finding on computed tomography or magnetic resonance imaging studies obtained for other purposes. The justification for the removal of a nonfunctional tumor lies in the size of the adrenal mass; a lesion that is large (>5 cm) at diagnosis or is shown to be enlarging on serial examinations has a greater possibility of being malignant.

Metastatic lesions from nonadrenal primary tumors are included in the nonfunctional category. Most commonly metastasizing from lung, breast, kidney, or skin (melanoma), these tumors may be indistinguishable from benign adenomas on preoperative images. If the tumor is a solitary metastasis, laparoscopic removal may be appropriate, although the benefit to the patient must be carefully considered. There are a few relatively small studies of such tumors in the literature.[13,14]

Functional adrenal tumors arise from the adrenal cortex or medulla and are manifested in a variety of ways (see Table 19–1). Because these tumors are relatively uncommon, their discovery is frequently delayed. The diagnosis and evaluation of these various pathologic states are beyond the scope of this chapter but can be found in standard texts on adrenal diseases.[15] The perioperative treatment of the various disease states is a critical element in the management of affected patients and must not be neglected.

Excessive size is a relative contraindication to laparoscopic adrenalectomy, and there is debate regarding the upper limit of adrenal size amenable to the laparoscopic approach. Most authors would agree that 10- to 12-cm masses can be removed laparoscopically.[11] But patients must be carefully selected because these larger masses are technically more difficult to remove and have a greater likelihood of representing adrenocortical carcinoma. There are now several series of larger (>5 cm) adrenal masses that have been reported.[16–18] Such lesions are infrequent and should be undertaken by experienced laparoscopic surgeons.

Laparoscopic adrenalectomy for adrenal cortical carcinoma is controversial because a poor laparoscopic resection may be harmful to the patient. These malignant lesions are generally large and invasive. However, there are some reports of successful laparoscopic removal of malignant adrenal tumors.[13,14,19] Just as in open dissection, care must be taken to minimize manipulation of the adrenal tumor, obtain wide margins, and avoid tumor spillage.

Previous surgery may be a relative contraindication to laparoscopic adrenalectomy, in that extensive scarring may make the procedure more difficult. With the option of transperitoneal or retroperitoneal laparoscopic access, there is more flexibility in patients with previous surgery and these patients can often undergo a laparoscopic procedure.

PATIENT PREOPERATIVE EVALUATION AND PREPARATION

Preoperative counseling covers the standard risks of surgery, as well as the specific risks of injury to spleen or liver, kidney, and major vascular structures. Discuss the possibility of conversion to open surgery, including personal experience with the intended procedure. Most large series report a low conversion rate of 2% to 5%.[20,21] Administer broad-spectrum intravenous antibiotics at the outset of the procedure and continue them for 24 hours. After administration of general anesthesia, place a Foley catheter and orogastric tube.

Treat the patient who has pheochromocytoma for several weeks before surgery with an appropriate agent. I use phenoxybenzamine, a long-acting α-adrenergic blocker, but others have reported using selective α-blockers or calcium channel blockers. Consult with the anesthetist as part of preoperative planning. Give patients with glucocorticoid-producing tumors perioperative hydrocortisone. Because the contralateral adrenal

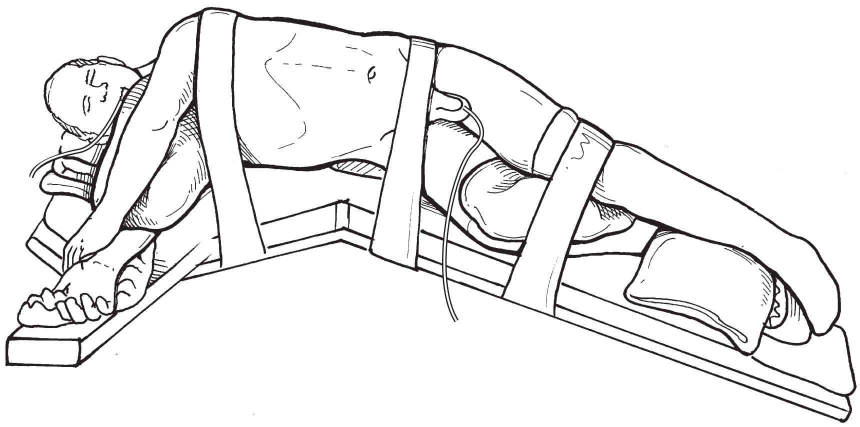

FIGURE 19–1. In the transperitoneal approach the patient is placed in the modified flank position. The flank is placed directly over the break in the table so that the table can be flexed. The arms are carefully padded and secured. Wide cloth tape is used to secure the hips and chest.

TABLE 19–1. INDICATIONS FOR LAPAROSCOPIC ADRENALECTOMY

Functional Adrenal Tumors
Aldosterone-secreting tumor (Conn's syndrome)
Cortisol-secreting tumor (Cushing's syndrome)
Virilizing tumor
Pheochromocytoma
Nonfunctional Adrenal Tumors
Incidental adrenal mass >5 cm
Adrenal mass <5 cm but enlarging on serial examinations
Solitary metastasis from nonadrenal primary (e.g., breast, lung, kidney, skin)

is severely suppressed by the excess function of the tumor, cortisol replacement is often necessary for weeks to months after surgery. Patients with aldosterone-secreting tumors need to undergo several weeks of adequate hypertension control and correction of hypokalemia.

OPERATING ROOM CONFIGURATION AND PATIENT POSITIONING

Transperitoneal Approach

For transperitoneal adrenalectomy, place the patient in a modified flank position, 20 to 30 degrees back from vertical (Fig. 19–1). Use a beanbag device or a padded roll to keep the patient in position, if needed. Do not flex the table, except in the event of conversion to open surgery, in which case the table is flexed as needed to improve exposure. Extend the lower arm on a standard arm board and place an axillary roll just caudad to the axilla. Bring the upper arm across the body and support it with a Krause (sling) rest, double arm board, or several pillows. Adequately extend the upper arm to avoid undue strain on the upper shoulder joint. Pad both arms under the elbows and wrists. Place sequential pneumatic compression devices on the legs, which are gently flexed with a pillow between them and foam under the feet and ankles. Place wide tape strips across the hips and chest to secure the patient to the table. Now laterally tilt the operating table to change body position during the procedure. Both surgeon and assistant stand on the patient's ventral side (Fig. 19–2). The technician stands at the patient's feet or on the opposite side, and two monitors are positioned so that all members of the surgical team can view the procedure.

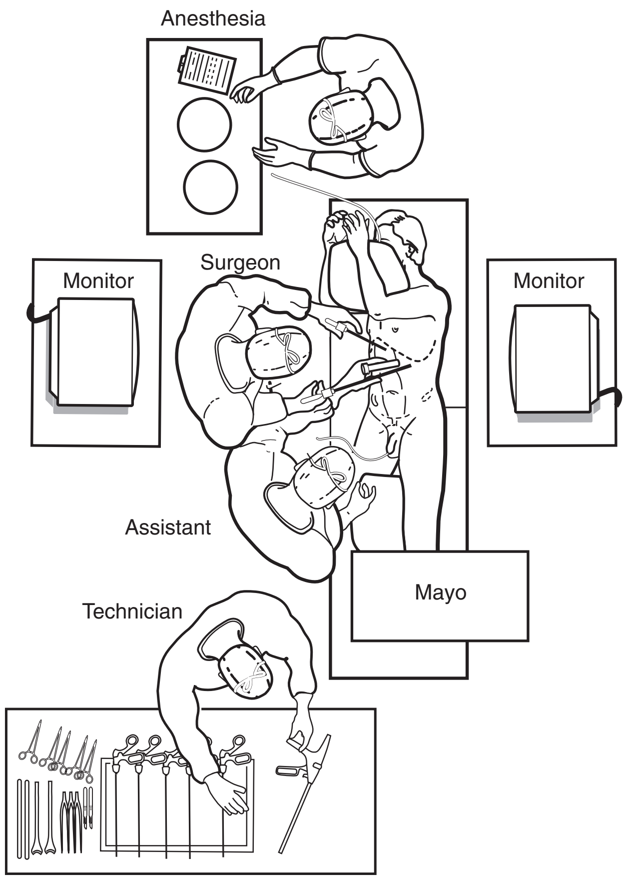

FIGURE 19–2. OR setup for the transperitoneal approach.

Retroperitoneal Approach

Patient positioning in the retroperitoneal approach is similar to the transperitoneal approach except that the patient is in a full flank position (Fig. 19–3). Place the flank directly over the table break with the patient on a beanbag. Flexion of the table is recommended to open the space between the 12th rib and the iliac crest. With the table flexed, adjust the bed to create a level operating surface (usually by raising the head). Extend both

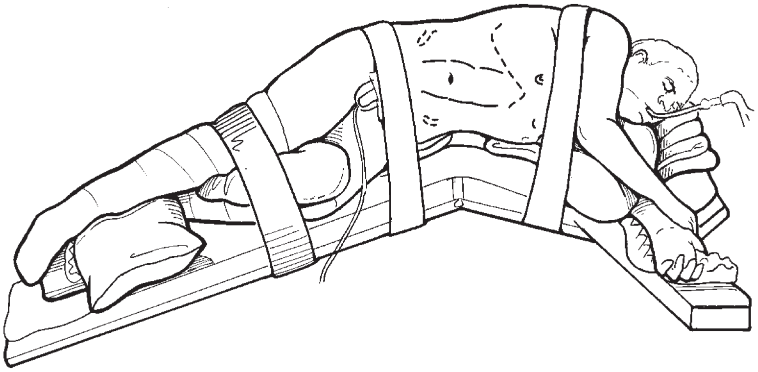

FIGURE 19–3. In the retroperitoneal approach patient positioning is similar to the transperitoneal approach except the patient is in a full flank position. Again the flank is directly over the table break. Flexion of the table is recommended when the space between the 12th rib and the iliac crest is very narrow. With the table flexed, the head is lowered to create a level operating surface. Both arms are extended in front of the patient as previously described, and an axillary roll is carefully placed.

arms in front of the patient as previously described, and carefully place an axillary roll. The leg positioning is the same as for the transperitoneal approach. For the retroperitoneal approach, the surgeon and assistant stand at the patient's back.

The configuration in the operating room also allows visualization of the procedure by the entire surgical team (Fig. 19–4).

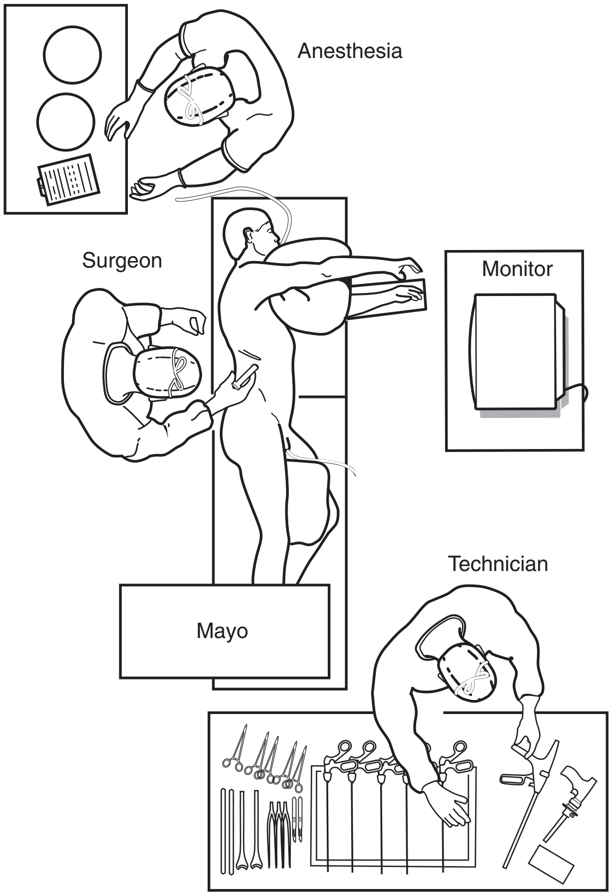

FIGURE 19–4. OR setup for the retroperitoneal approach. The surgeon and assistant stand at the patient's back.

TROCAR PLACEMENT

Transperitoneal Approach

Left-Sided Adrenalectomy

For left-sided adrenalectomy, place three ports along the costal margin initially, with an optional fourth port if additional retraction is needed. The primary site is located 2 fingerbreadths below the costal margin in the midclavicular line. In the lateral position, most patients have a slight hollow at this site. Use a 10-mm port for this primary laparoscope port. Place secondary ports just below the costal margin. Locate a 5-mm port medially and cephalad, just lateral to the rectus abdominis muscle; use this port primarily for retraction and irrigation-aspiration. Place another 5-mm port lateral and caudad to the primary site to accommodate scissors, dissectors, and a clip applier (Fig. 19–5). If difficult anatomy or dissection requires the use of a fourth port, place it laterally. Some flexibility in port use allows exposure of the adrenal to be optimized by shifting the laparoscope according to anatomy and body habitus. This setup is considered a lateral transperitoneal approach.

Right-Sided Adrenalectomy

For right-sided transperitoneal adrenalectomy, four ports are always needed because the liver must be retracted throughout the procedure. As with the left side, place the primary 10-mm port in the midclavicular line. Take care to access this site in a caudad direction to avoid impaling the liver on initial entry. Place subsequent 5-mm ports along the costal margin as shown in Figure 19–6. Alternate between the ports as needed, depending on the difficulty of accessing the short adrenal vein.

Retroperitoneal Approach

The port placement for retroperitoneal access is the same for right-sided and left-sided adrenalectomy. Place the primary site using a 2-cm incision placed between the tip of the 12th rib and the iliac crest. After finger dissection to develop the retroperitoneal space, use a Hasson port here. Two additional ports are routinely used, and a fourth port is optional. Place the laparoscope at the primary port. Place the second port posterior to the primary site, just below the angle formed by the 12th rib and the vertically oriented paraspinous muscles (Fig. 19–7). Place the third port 3 to 4 cm medial and slightly superior to the primary site in the anterior axillary line, taking care to avoid the peritoneal reflection. This arrangement allows the camera to sit between the two working ports, optimizing orientation. The posterior port must not be too close to the paraspinous

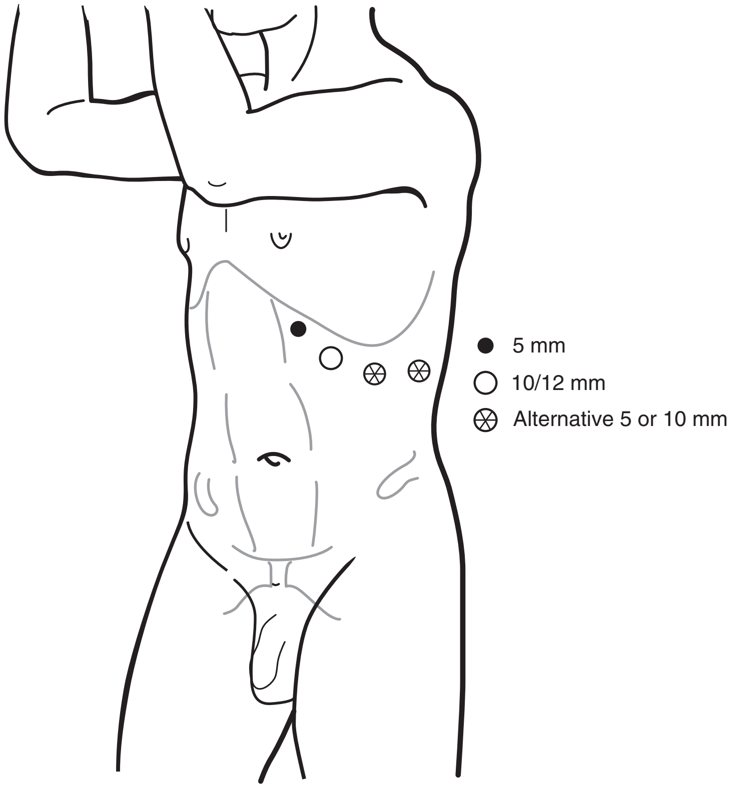

FIGURE 19–5. For transperitoneal left-sided adrenalectomy, three ports are placed along the costal margin initially, with an optional fourth port if additional retraction is needed. The primary site is located two fingerbreadths below the costal margin in the midclavicular line. A 10-mm port is used for the primary laparoscope port. Secondary ports are also placed just below the costal margin. A 5-mm port is medial and cephalad, just lateral to the rectus abdominis muscle. This port is primarily used for retraction and irrigation-aspiration. A 5-mm port is placed lateral and caudad to the primary site to accommodate scissors, dissectors and a clip applier.

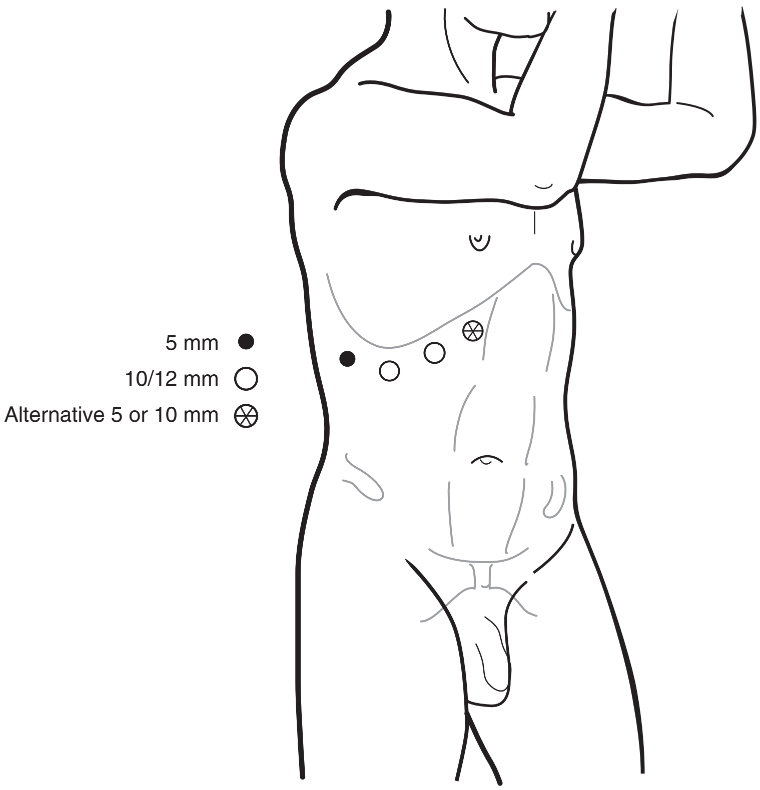

FIGURE 19–6. For transperitoneal right-sided adrenalectomy four ports are always used because the liver requires active retraction. Similar to the left side, the primary 10-mm port is placed in the midclavicular line. The superomedial port is usually a 10-mm port to accommodate a large fan retractor, although a 5-mm retractor could also be used. The third port is 10 mm and is commonly used for the laparoscope, and the fourth (lateral) port can be 5 mm. The surgeon may alternate between ports 1 and 3 for initial dissection, and ports 2 and 4 when the medial port is used for retraction of the liver.

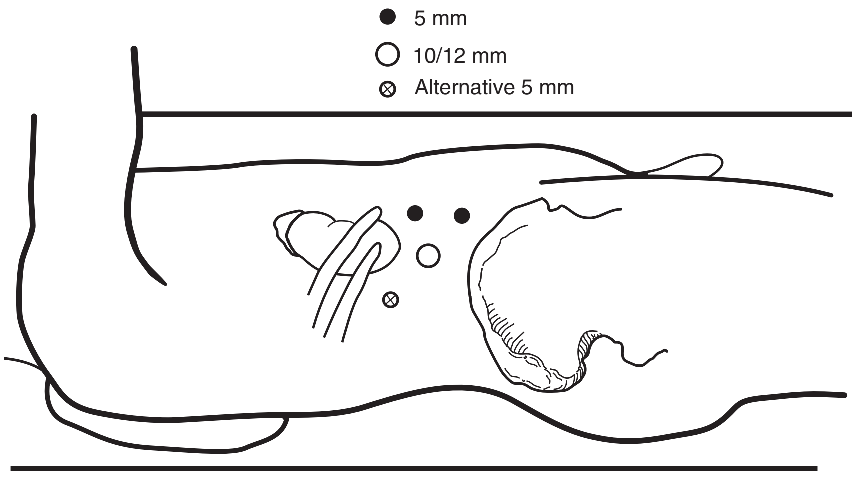

FIGURE 19–7. For trocar placement in the retroperitoneal approach, the primary site is a 2-cm incision placed between the tip of the 12th rib and the iliac crest. After finger dissection to develop the retroperitoneal space, a Hasson port is used here. Two additional ports are routinely used and a fourth port is optional. The port placement is similar on the right and left sides. The laparoscope is placed at the primary port. The second port is placed 3 to 4 cm medial and slightly superior to the primary site in the anterior axillary line. The third port is placed posterior to the primary site, just below the angle formed by the 12th rib and the vertically oriented paraspinous muscles. This allows the camera to sit between the two working ports to optimize orientation. The posterior port must not be too close to the psoas muscle as this may limit the range of motion. These ports may be 5 mm or 10 mm depending on the surgeon's preference and availability of instruments. The optional fourth port may be used for retraction and is placed in the anterior axillary line, about 5 to 7 cm inferior to the working port.

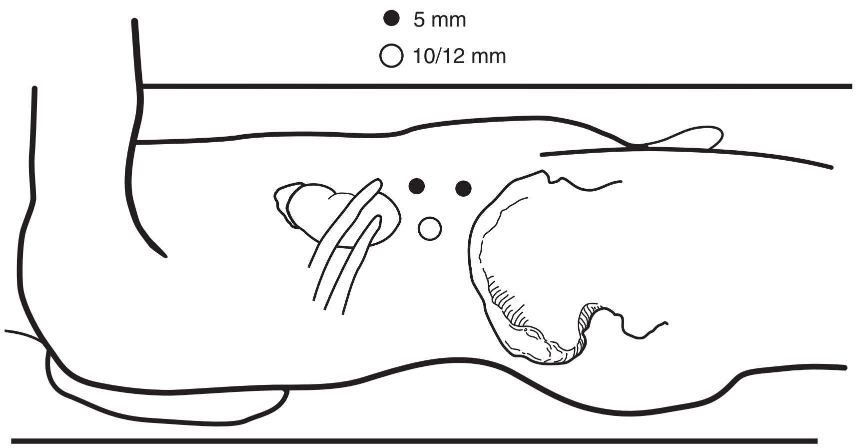

FIGURE 19–8. An alternative is to use the two anterior axillary ports and omit the posterior port site.

muscles because this may limit the range of motion. These ports may be 5 mm or 10 mm, depending on preference and availability of instruments. I use 5-mm ports, which accommodate dissecting instruments, suction, and a clip applier. The optional fourth port may be used for retraction and is placed in the anterior axillary line, about 5 to 7 cm inferior to the working port. An alternative is to use the two anterior axillary ports and omit the posterior port site (Fig. 19–8).

PROCEDURE

Transperitoneal Approach

Left-Sided Adrenalectomy

Create pneumoperitoneum with CO_2 according to preference. Inspect the peritoneal cavity and trocar sites first for evidence of access-related injury. Anatomic landmarks are identified and orientation is achieved.

The initial step is to mobilize the colon. On the left side, there are consistently lienophrenic attachments of the splenic flexure to the abdominal wall. With a curved grasper and cautery scissors, divide these attachments and incise the line of Toldt along the descending colon and sweep the colon medially. Extend this lateral incision high up along the spleen to release the spleen and allow it to fall by gravity away from the suprarenal fossa. This incision needs to be close to the spleen in order to avoid injury to the diaphragm (Fig. 19–9). Further mobilize the spleen by making a transverse incision with electrocautery through the superficial attachments to the transverse colon (the lienocolic ligaments), which overlay the left kidney. Incise these attachments to allow both the colon and spleen to fall away from the upper pole of the kidney. Sufficient mobilization has been accomplished when the renal hilum is exposed (Fig. 19–10).

Identification of the adrenal gland is the next task. The left adrenal sits within the perinephric fat at the superior pole of the left kidney. The left adrenal vein generally descends from the inferomedial aspect of the gland to the left renal vein

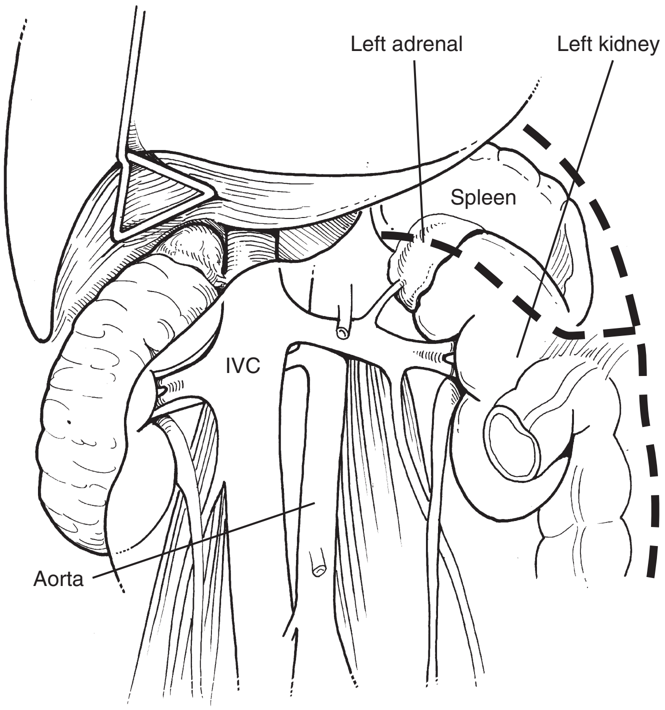

FIGURE 19–9. The lateral incision is extended high up along the spleen so that the spleen is released and allowed to fall away from the suprarenal fossa. The incision is made close to the spleen to avoid injury to the diaphragm. IVC, inferior vena cava.

(see Fig. 19–10). It is not necessary to completely expose the renal vessels because the adrenal vein may be divided near the adrenal gland. In the event of a difficult dissection or pheochromocytoma, however, identify the adrenal vein early in the operation, where it joins the left renal vein (Fig. 19–11). Once the adrenal vein is identified, perform careful vascular dissection with a right-angle dissector to expose a sufficient length of vein. Place standard laparoscopic clips—two proximally, one distally—and divide the vein (Fig. 19–12).

The characteristic golden-orange hue of the adrenal gland can be confused with the surrounding yellow fatty tissue. Careful and persistent dissection will lead to proper identification of the adrenal gland. The splenic vessels course near the left adrenal, but there is a clear plane between the splenic vessels/tail of pancreas and the anteromedial surface of the adrenal gland. The splenic artery pulsations are a recognizable landmark and dissection should not be carried out medial to this artery.

With the adrenal borders clearly identified, carry out complete dissection. The adrenal is fragile and will bleed easily if mishandled. I prefer to dissect the patient away from the adrenal gland. This can be done by lifting or pushing the adrenal rather than grasping it. Use electrocautery to effectively divide the many small feeding vessels. The remainder of the dissection consists of freeing the adrenal from its bed. Infrequently, additional variant veins may require clips and need to be identified. Despite elaborate descriptions in anatomy texts, there are generally no specific arteries that need to be identified. Rather, the

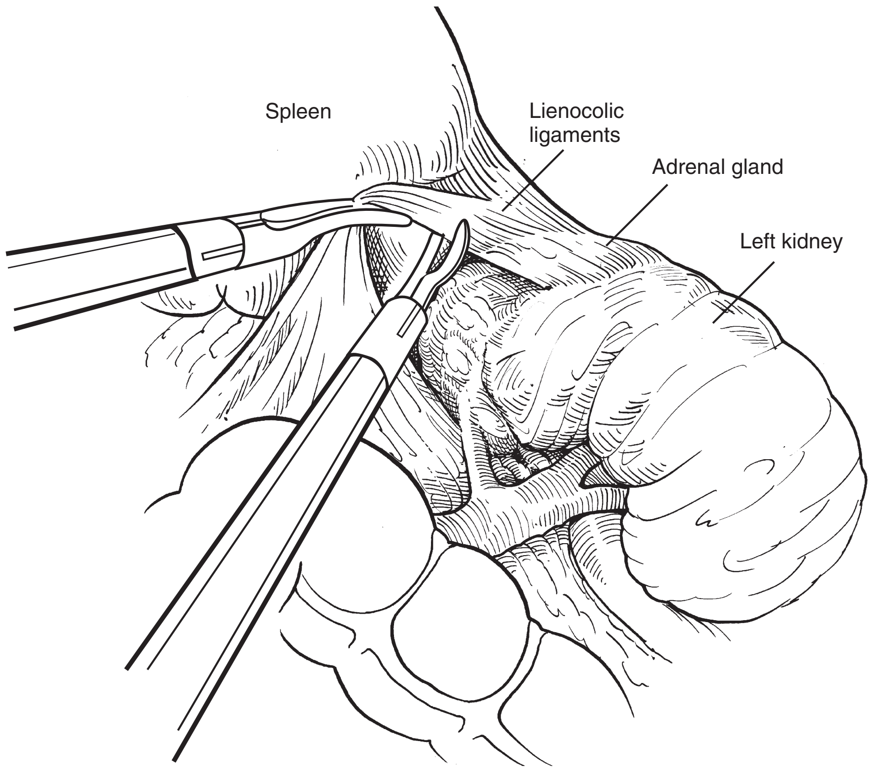

FIGURE 19–10. Additional mobilization of the spleen is accomplished by a transverse incision through the lienocolic ligaments.

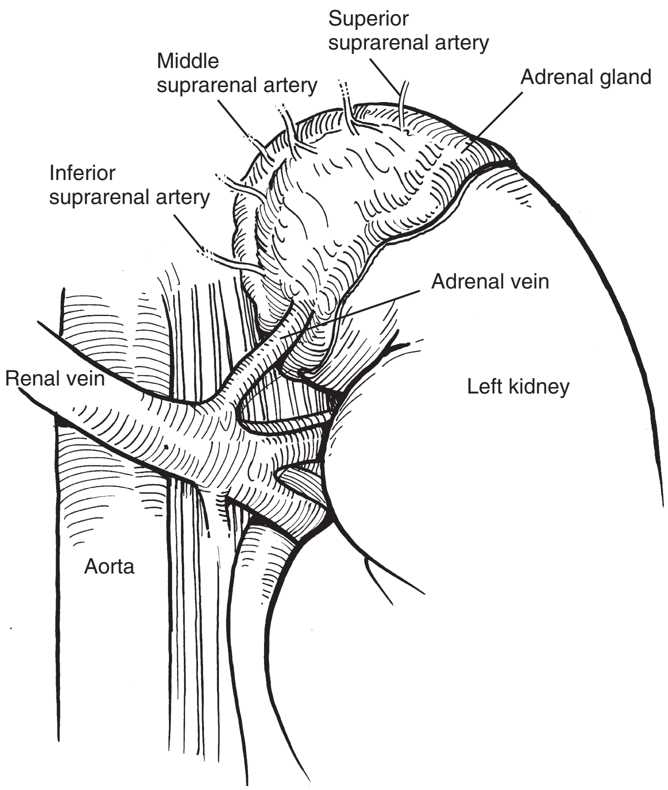

FIGURE 19–11. Anatomy of the left adrenal gland. The left adrenal vein is usually found medial to the level of insertion of the gonadal vein on the renal vein and at the lateral edge of the aorta. Practically speaking, the adrenal vein is usually more medial than expected.

arterial supply consists of an extensive array of small arteries around the medial side of the adrenal that can be easily handled with electrocautery or other dissecting energy (Fig. 19–13).

Once dissected entirely, place the adrenal into a retrieval bag and remove it through the largest port site (Fig. 19–14). Close the port sites in standard fashion (see Chapter 4).

Right-Sided Adrenalectomy

Carry the dissection down along the ascending colon and medially just below the liver until the colon falls away, exposing the kidney. There is often minimal or even no mobilization of the colon if the suprarenal fossa is easily exposed by lifting up the liver. Mobilize the liver from its abdominal wall attachments high up along its lateral aspect (Fig. 19–15). Retraction of the liver, which is necessary to sufficiently uncover the adrenal gland and complete the dissection, can be achieved with a retractor through either the most medial or most lateral port (Fig. 19–16).

The right adrenal gland is closer to the inferior vena cava (IVC) than the left adrenal is to the aorta, which makes this side trickier. The right adrenal vein usually arises from the posterolateral aspect of the IVC (Fig. 19–17). If the adrenal gland is readily identified, dissect right along the edge of the gland. I expose the IVC directly and extend this dissection up to the top of the adrenal gland. Just above the junction of the IVC and renal vein, use a blunt retractor to push the adrenal gland laterally, away from the IVC, creating a working space. Divide the vessels along the medial edge of the adrenal with electrocautery until the short adrenal vein is identified. At this point, expose the short adrenal vein with a right-angle dissector

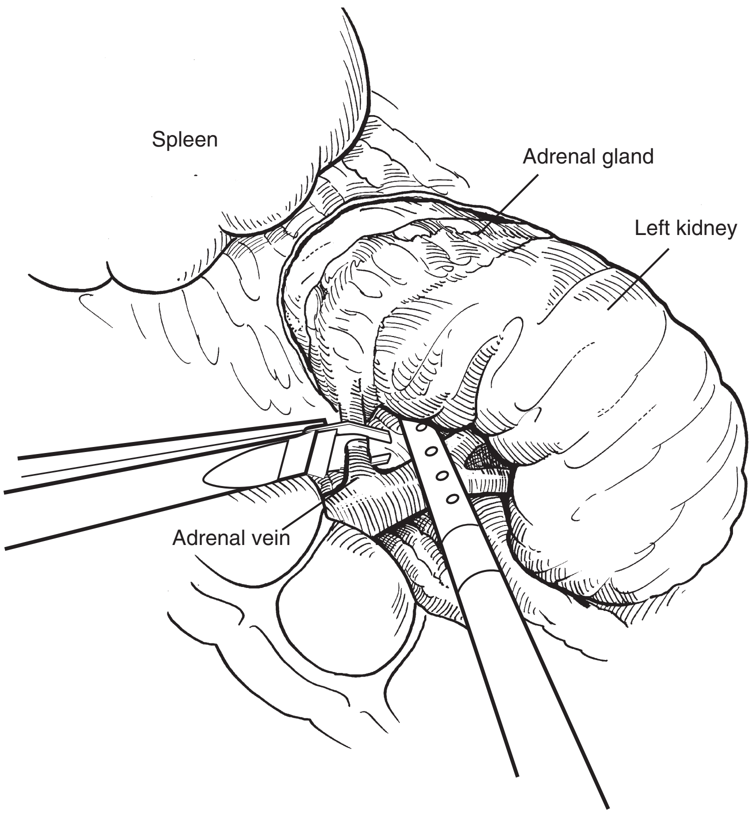

FIGURE 19–12. After the vein is ligated and divided, complete dissection is performed. This can be done by lifting or pushing the adrenal rather than grasping it. Electrocautery effectively divides the many small feeding vessels. The remainder of the dissection consists of freeing the adrenal from its bed. Infrequently, additional variant veins may require clips and should be identified.

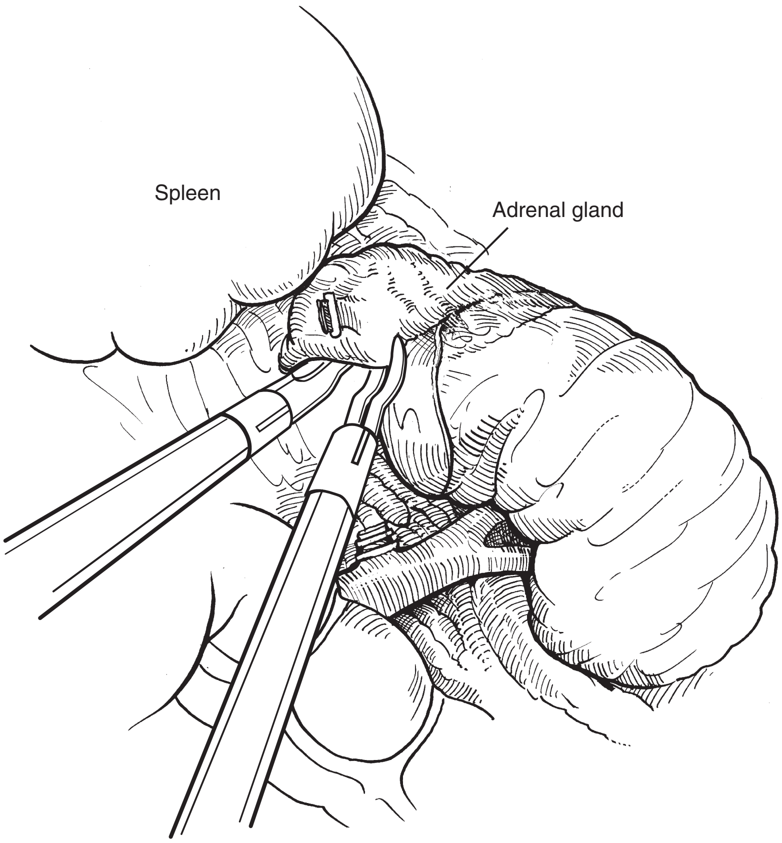

FIGURE 19–13. Once the adrenal vein is divided, the adrenal gland is separated from the upper pole of the kidney and freed posteriorly, leaving the superior attachments, which are then divided with electrocautery or other energy.

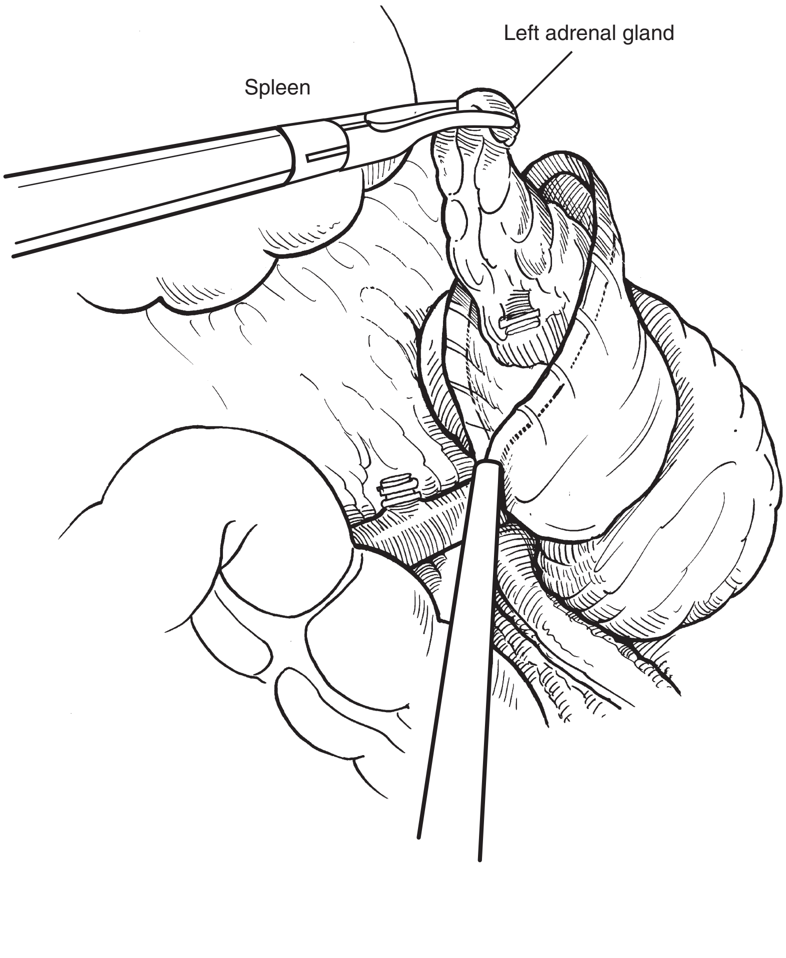

FIGURE 19–14. The dissected adrenal gland is placed into a commercial retrieval pouch and removed through the largest port site.

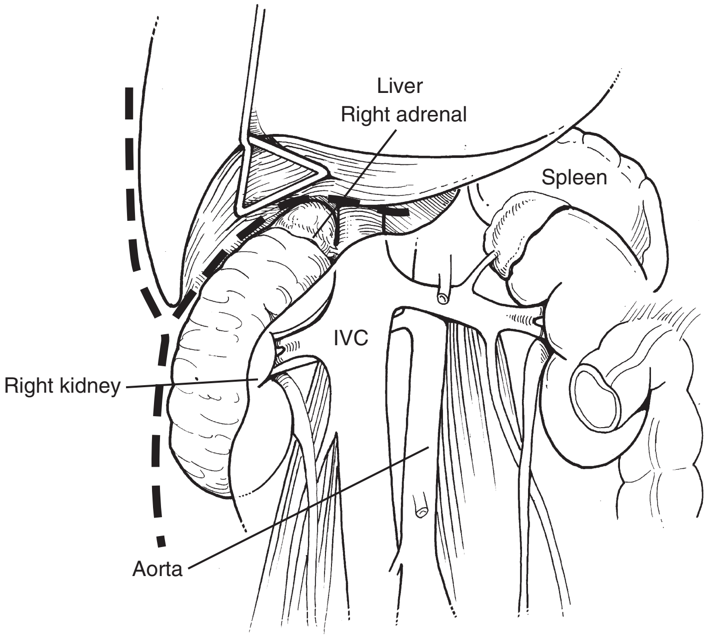

FIGURE 19–15. During a right-sided, transperitoneal adrenal dissection, peritoneum is opened along the ascending colon and medially just below the liver until the colon falls away sufficiently from the kidney. As with the spleen, the liver is mobilized from its abdominal wall attachments high up along its lateral aspect, staying close to the liver to avoid diaphragmatic injury. IVC, inferior vena cava.

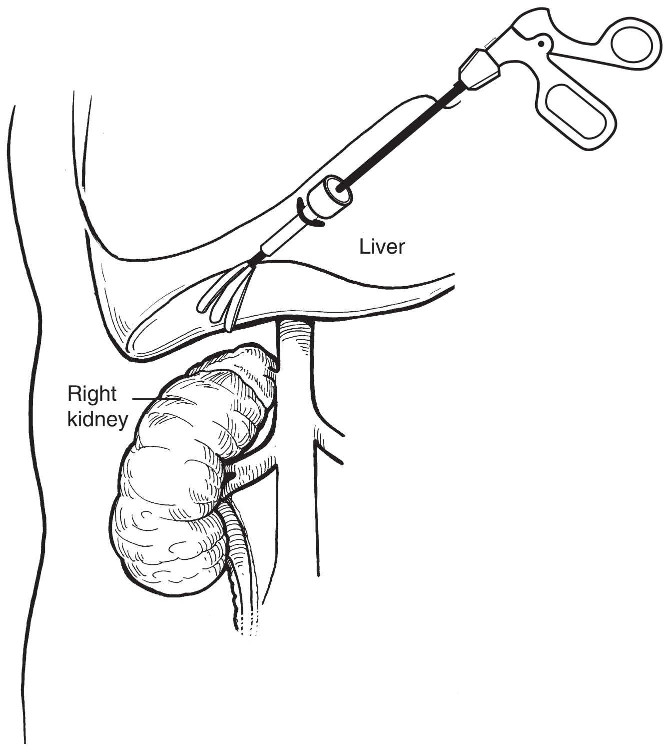

FIGURE 19–16. Retraction of the liver is necessary to sufficiently uncover the adrenal gland and complete the dissection. This can be achieved with a fan retractor through the most medial port.

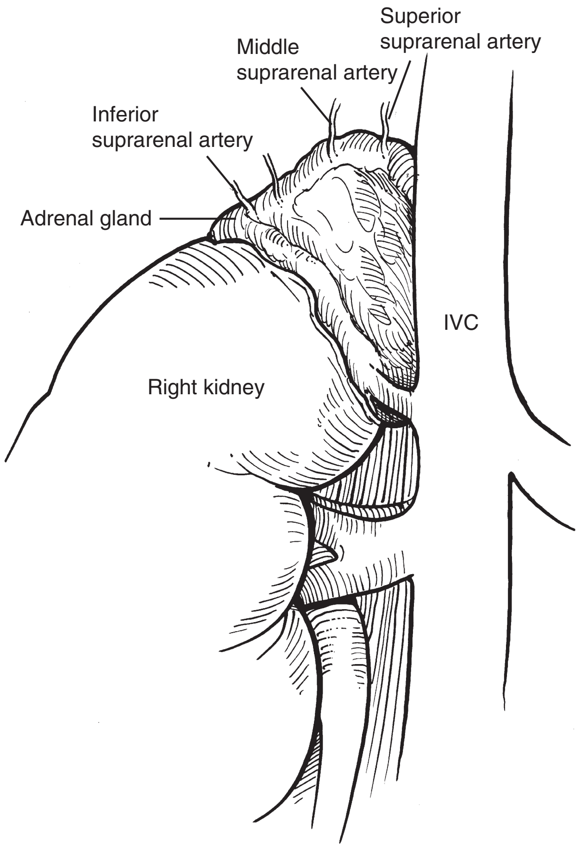

FIGURE 19–17. Anatomy of the right adrenal gland. The adrenal gland on the right side lies close to the inferior vena cava, and the right adrenal vein usually arises from the posterolateral aspect of the inferior vena cava (IVC).

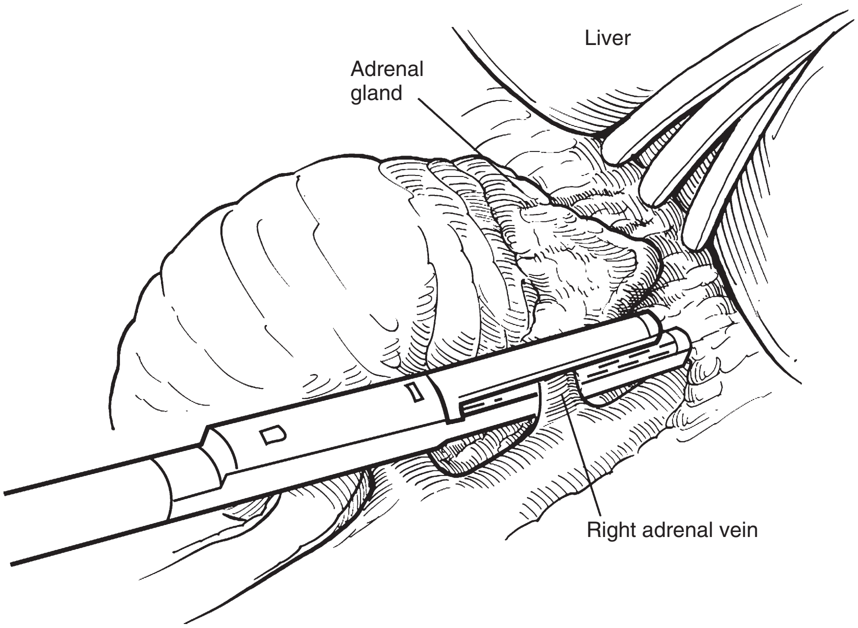

FIGURE 19–18. At the medial aspect of the adrenal, the short adrenal vein is identified, exposed with a right-angle dissector and divided between clips or if there is adequate room divided using the endovascular stapler.

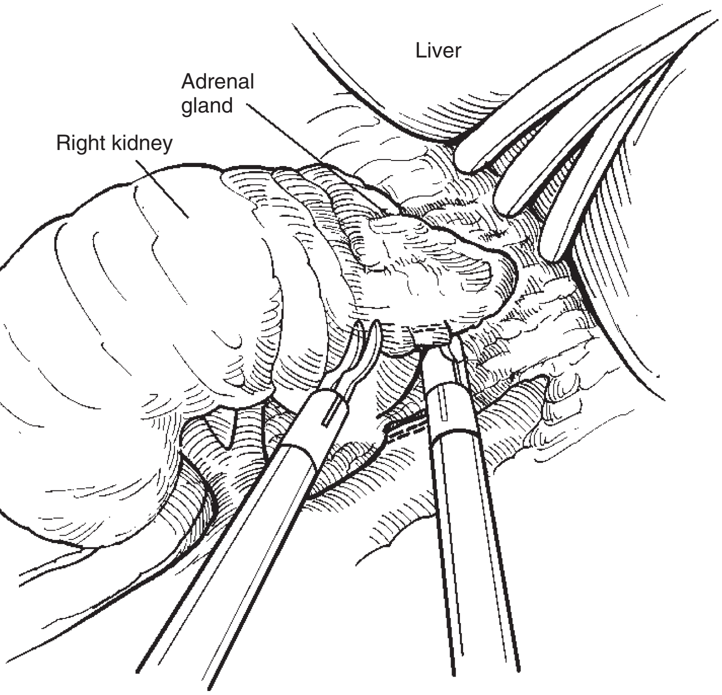

FIGURE 19–19. With the main adrenal vein divided, the remainder of the dissection is performed with cauterization of small vessels feeding the adrenal. After division of the adrenal vein the adrenal is dissected from the edge of the vena cava. The inferior attachments to the upper pole of the kidney are then released.

and divide it between clips or with an endovascular GIA stapler (Fig. 19–18). Surgeons who choose to divide the adrenal vein with the vascular stapler must ensure that there is adequate space between the vena cava and the edge of the adrenal gland in order to prevent avulsion of the adrenal vein during insertion and activation of the stapler. Venous variations may exist, with additional venous branches arising from the right renal vein or even the hepatic veins.[22] These veins must not be overlooked during the dissection. As on the left, simply divide the array of adrenal arteries with cautery (Fig. 19–19).

With the main adrenal vein divided, the remainder of the dissection is less worrisome. When the adrenal gland is completely free, place it in a retrieval bag and remove it through a port site. Close the incisions in standard fashion.

Retroperitoneal Approach

Techniques for Both Sides

The key to the retroperitoneal approach lies in understanding the orientation, which is distinctly different from the transperitoneal approach. Instead of looking down on the kidney and adrenal gland from above (very similar to an open transperitoneal view), I approach the kidney from behind with an end-on view of the lower pole. This unfamiliar orientation makes this a daunting procedure for the novice laparoscopist. Most general surgeons seldom use a retroperitoneal approach, but for urologists experienced with retroperitoneal laparoscopic nephrectomy, this approach offers flexibility in patient selection. Some surgeons choose this preferentially,[23,24] but nearly 80% of

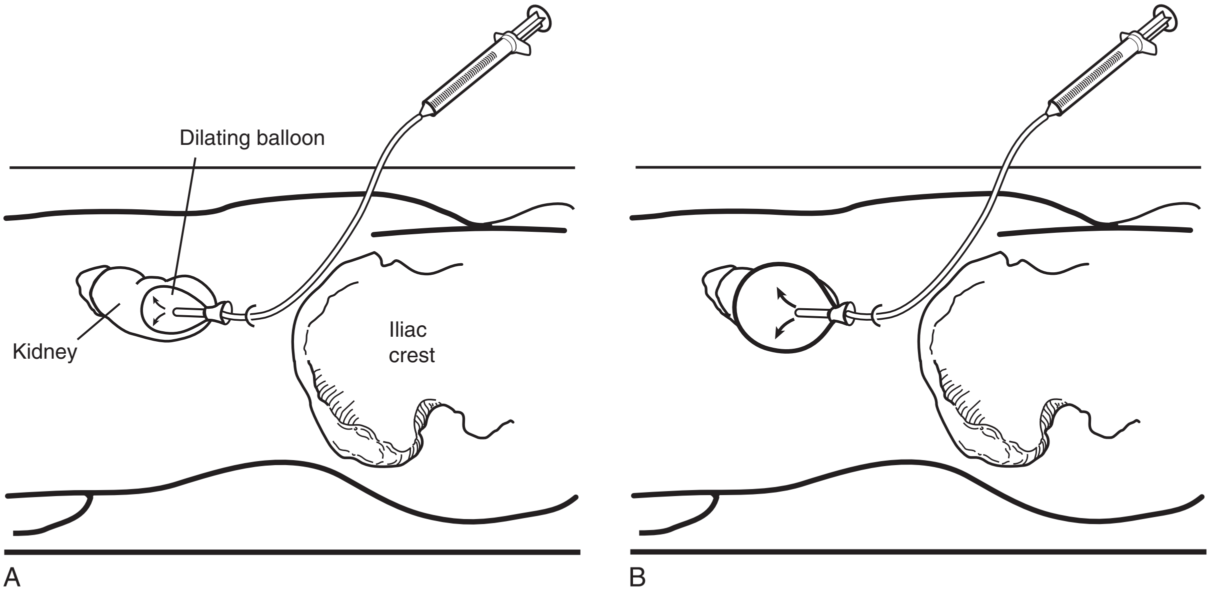

FIGURE 19–20. Access into the retroperitoneal space is confirmed by inserting one finger and palpating the inner surface of the 12th rib above and the iliac crest below. This finger can also identify the psoas muscle and begin to sweep all anterior structures away. One may also create the retroperitoneal working space with a constructed catheter balloon device or a commercial dilating balloon (Origin Medsystems, Menlo Park, CA). *A,* The trocar-mounted balloon is placed posteriorly along the abdominal wall and cephalad from the incision. *B,* This mobilizes the kidney and perinephric fat away from the back wall.

surgeons prefer a transperitoneal lateral approach, as described earlier.[11] In experienced hands, there is no difference in outcomes or cost between these two approaches.[25–28] Surgical approach should depend on the skill, experience, and preference of the surgeon.

Through the primary incision, perform a muscle-splitting dissection with exposure created by S-retractors. Confirm access to the retroperitoneal space by inserting one finger and palpating the inner surface of the 12th rib above and the iliac crest below. Also use this finger to identify the psoas muscle and begin to sweep the kidney anteriorly. Create the retroperitoneal working space with a commercial dilator or Gaur balloon using the finger from a size 9 glove and a 20-French red rubber catheter (Fig. 19–20). Place the trocar-mounted balloon posteriorly along the abdominal wall and cephalad from the incision. This mobilizes the kidney and perinephric fat away from the back wall. Then secure the Hasson port and the pneumoretroperitoneum is generated. Place and secure additional ports.

Positioning the balloon dissector more cephalad facilitates more rapid access to the adrenal gland. Sometimes it is useful to position the balloon a second time and reinflate it. The initial view is nearly always somewhat tattered, but key landmarks can be identified. The psoas muscle is easily seen and serves as a guide for longitudinal orientation. Many random veils of tissue near the psoas can be swept aside or divided to clarify the view. Dissecting medially, the great vessels can be identified by their pulsations as they run parallel to the psoas fibers. The renal vessels are found by identifying the pulsations of the posteriorly situated renal artery, although exposure of these vessels is not always necessary. The kidney may be relatively difficult to identify if there is an abundance of perinephric fat. If the patient is thin and the adrenal mass prominent, locating the area of interest may be straightforward. However, a small mass in the midst of abundant fat can present a challenge. In these cases, intraoperative sonography is helpful.

Left-Sided Adrenalectomy

Once the initial dissection is complete and the landmarks and orientation have been identified, locate the adrenal mass. Because there is often scant fatty tissue posterior to the adrenal gland, the gland's golden hue is quickly noted. Carry the dissection cephalad along the psoas to the upper pole of the kidney. I tend to approach the adrenal from a lateral angle and then find the adrenal vein along the inferomedial border, where it can be exposed, clipped, and divided. If locating the adrenal is difficult, or if the mass is a pheochromocytoma, find the adrenal vein by identifying the left renal vessels and locating the junction of the adrenal vein with the left renal vein (Fig. 19–21). Because the adrenal vein tends to course along the medial aspect of the kidney, keep the dissection strictly posterior, in order to keep the kidney and adrenal gland from falling down into the field of view. After dividing the adrenal vein, detach the remainder of the gland, remembering to lift and push, rather than grasp, the adrenal gland tissue.

Once the adrenal is completely mobilized, place a laparoscope through one of the secondary ports so that the gland may be removed through the largest incision (the primary site). Place the gland in a retrieval bag and remove it. Close the port sites in standard fashion.

Right-Sided Adrenalectomy

The right side is somewhat more difficult with a retroperitoneal approach because of the position of the adrenal gland and the length of the adrenal vein in relation to the IVC (Fig. 19–22). The same principles of retroperitoneal laparoscopy apply. Move the dissection cephalad along the psoas muscle, paying careful attention to orientation. The kidney is held anteriorly by its own attachments or with an optional retractor. Locate the adrenal gland before approaching the adrenal vein. Identify and dissect the IVC above the renal vessels, if needed. The right

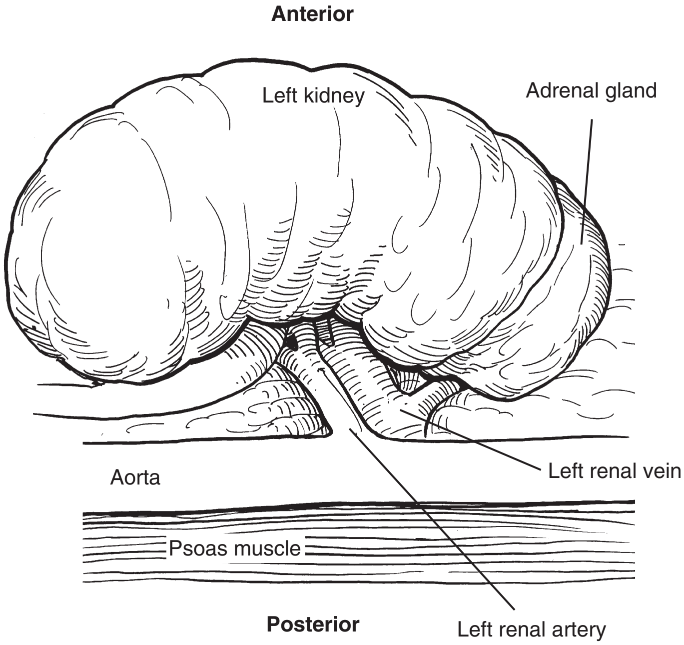

FIGURE 19–21. Once the initial dissection is complete and the landmarks and orientation identified, the adrenal mass must be located. Because there is often scant fatty tissue posterior to the adrenal, the golden hue may be quickly noted. The dissection should be carried cephalad along the psoas to the upper pole of the kidney. I tend to approach the adrenal from a lateral angle and then find the adrenal vein along the inferomedial border, where it can be exposed, clipped, and divided. If locating the adrenal is difficult, or if the mass is a pheochromocytoma, the adrenal vein can be found first by identifying the left renal vessels and locating the junction of the adrenal vein with the left renal vein.

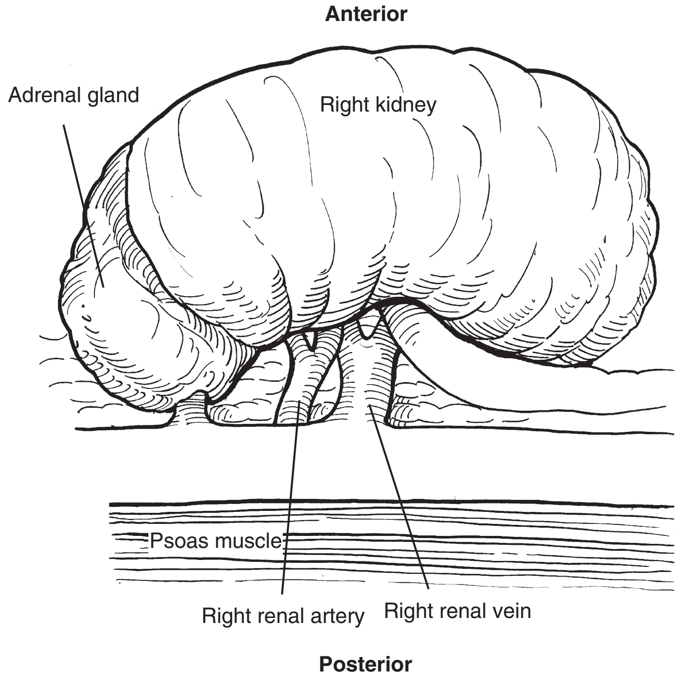

FIGURE 19–22. The right side is somewhat more difficult with a retroperitoneal approach because of the position of the adrenal and the length of the adrenal vein in relation to the inferior vena cava. The same principles of retroperitoneal laparoscopy apply. Dissection moves cephalad along the psoas muscle with careful attention to orientation, so that the renal vein is not mistaken for the adrenal vein. The kidney is held anteriorly by its own attachments or by an optional retractor. The adrenal gland must be located before the adrenal vein can be approached. Identification and dissection of the inferior vena cava above the renal vessels may be helpful but may also be difficult. The right adrenal rests somewhat more medial to the kidney than the left adrenal, and the upper pole of the kidney may interfere with exposure of the adrenal.

adrenal gland rests somewhat more medial to the kidney than the left gland, and the upper pole of the kidney may interfere with exposure of the gland. Once the adrenal gland is located, mobilize and lift it anteriorly to expose the adrenal vein, which can then be clipped and divided. As with the other approaches, mobilize the remainder of the adrenal gland with electrocautery and remove it in a retrieval bag. Close the port sites as previously described.

Additional Tips and Variations

Instead of electrocautery, it is possible to use other energy sources, such as harmonic scalpel or plasmakinetic energy, for much of the dissection. I prefer an L-hook electrocautery device. Intraoperative laparoscopic sonography is particularly helpful when the tumor is small or is buried in a large amount of adipose tissue. Watch for accessory or aberrant veins, even after securing the main adrenal vein. Generally, no significant arteries are identified. Because the dissection circumscribes the gland, use electrocautery to divide arterial feeders in the case of smaller vessels and between clips for larger vessels. The medial dissection is always the most critical. As the adrenal is freed and moved away from the major structures medially, there is less risk of aberrant vessels, less risk of disaster, and easier breathing for the surgeon.

Not surprisingly, the introduction of robotics into laparoscopy has led some to investigate the potential benefit of robotic-assisted laparoscopy for adrenalectomy. Although robotic assistance has been helpful for procedures that require extensive suturing, there has not been a significant benefit for adrenalectomy.[29] This is an expected outcome because laparoscopic adrenalectomy has been mastered early on by the community of laparoscopic surgeons.

Is there a role for adrenal-sparing procedures? There are certainly cases in which both adrenal glands are pathologically involved (bilateral adenomas, von Hippel–Lindau). Even in the face of a normal contralateral adrenal, there may be a case (as for nephron-sparing renal surgery) for preserving as much functioning adrenal tissue as possible. From a technical standpoint, a partial adrenalectomy can be done.[30,31] Generally, these tumors are smaller and more laterally situated, although some authors have even divided the main adrenal vein, removed the tumor, and left a remnant of the adrenal with function confirmed by scintigraphy. I have performed partial adrenalectomies with a variable combination of cautery, harmonic scalpel, endoscopic stapling, and fibrin glue. Use caution, however, because the incidence of multifocal lesions is not known. One group has reported 27% multifocal lesions in patients with aldosterone-producing adenomas.[31]

POSTOPERATIVE CONSIDERATIONS

Remove the orogastric tube and Foley catheter at the end of the procedure. The patient continues on broad-spectrum antibiot-

ics for 24 hours. No wound drains are necessary. The most important aspect of postoperative care is the management of the specific endocrinologic problem, if any. The specific management regimens are beyond the scope of this text but may be administered by the surgeon or in consultation with an endocrinologist.

COMPLICATIONS

Complications of this procedure may be classified as access related, intraoperative, and postoperative.[32] Access-related complications are the same as for other laparoscopic procedures. Abdominal wall hemorrhage is uncommon with careful port placement and can be detected by inspecting the port sites at the end of the procedure. Cutaneous nerve injury is possible but less likely than in open surgery because of the small incisions. Visceral injury by the Veress needle remains an area of concern with vocal advocates for both the open (Hasson) and closed (Veress) access techniques. I have found the Veress needle to be quite safe for routine cases.

Intraoperative complications consist primarily of bleeding. Identify intraperitoneal organs during a transperitoneal procedure. Judicious use of electrocautery around the viscera should obviate most injuries. Always take care to keep the activated electrocautery probe in the field of view to avoid inadvertent thermal injury not observed during the procedure. During retroperitoneal procedures, remember the relative location of the intraperitoneal structures. Injury, especially thermal injury, can occur to structures not seen during this approach. Retractors may injure liver or spleen if not carefully placed and held because these structures are often out of the field of view. It is also imperative to maintain correct orientation. Surgical dissection that strays from the correct field can result in injury to pancreas, spleen, or other structures.

Bleeding is perhaps the most worrisome problem during adrenalectomy. The proximity of the great vessels, the renal vessels, and the splenic vessels makes adrenalectomy a challenging procedure. Correct identification of structures and orientation lessen this risk. Meticulous and cautious dissection in these areas is the hallmark of a skilled laparoscopist. The IVC in particular is both “friend and foe” to the laparoscopic surgeon. Identification of the IVC and careful dissection along it can be very helpful, as in open surgery. But an avulsed venous branch or cavotomy may be disastrous and often requires conversion to open surgery.

The adrenal gland itself is very vascular and fragile. It is worth restating that the adrenal must never be grasped directly. It is easily torn, and this injury results in persistent oozing that may make the remaining dissection impossible. It is better to retract the surrounding tissues away from the adrenal or to bluntly lift or push the adrenal to gain exposure.

Finally, the adrenal may be difficult to locate. In the patient with extensive perinephric fat and a small adrenal gland, it may be difficult to find the target mass. Intraoperative ultrasound is a valuable tool to direct the dissection through the fat to the adrenal gland. The golden-orange color of the adrenal is a helpful clue, but it may be difficult to distinguish beneath a thin layer of yellowish adipose tissue.

Postoperative complications are generally minor and include prolonged ileus, fever, wound infection, and port site problems. These occur infrequently and are generally self-limited. A small percentage of patients have prolonged neuromuscular problems due to intraoperative positioning or cutaneous nerve injury. The extent of these problems is not well known. An undetected bowel injury or delayed hemorrhage would be discovered in the postoperative period but has not occurred in my experience.

SUMMARY

Laparoscopic adrenalectomy is an excellent application of laparoscopic technology. Reports from many institutions around the world have demonstrated that this is a reliable and reproducible procedure. As with most laparoscopic procedures, the recovery time is significantly shorter and the cosmesis is better than with the open surgical approach. Accordingly, it has become the gold standard for most adrenal surgery.

Tips and Tricks: Left Transperitoneal Adrenalectomy

- Aggressively mobilize the spleen to expose the suprarenal fossa.
- Keep dissection lateral to the splenic vessels.
- Use laparoscopic sonography to help localize the adrenal within the perinephric fat.
- The left adrenal vein is found at the inferomedial border of the adrenal; once divided, this makes a better “handle” than the fragile adrenal parenchyma for lifting up the adrenal.
- If the adrenal is buried in fatty tissue, find the splenic vessels medially and the renal capsule laterally; the adrenal vein lies between the two at the upper edge of the renal vein.

Tips and Tricks: Right Transperitoneal Adrenalectomy

- The adrenal lies close to the IVC; create space between the two structures to facilitate the critical dissection of the adrenal vein.
- The short right adrenal vein usually runs transversely to the IVC.
- Close dissection right on the IVC may actually prevent inadvertent injury.
- Aggressively mobilize the liver from its lateral attachments and actively lift it with a retractor.
- If the adrenal gland seems to lie more posterior to the IVC, shift the laparoscope to work through the lateral ports while retracting the liver through the most medial port.

Tips and Tricks: Retroperitoneal Adrenalectomy

- Identify the key landmarks: psoas muscle, kidney (and hilar vessels), IVC, and/or aorta.
- Locate the adrenal gland by knowing its position relative to the landmarks.
- Use laparoscopic sonography to help localize the adrenal gland within the perinephric fat.
- Keep the line of dissection posterior along the psoas muscle so that the kidney maintains its anterior attachments.
- Left adrenal vein is found at the inferomedial border of the adrenal gland.
- Right adrenal vein is short, transverse, and medial to the adrenal gland.

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CHAPTER 20

Laparoscopic Pelvic Lymph Node Dissection

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D. Duane Baldwin

Laparoscopic pelvic lymph node dissection (LPLND) has undergone a cyclic rise and fall over the past 2 decades. In the early 1990s, enthusiasm developed when it was initially demonstrated that the obturator nodal tissue could be removed safely using a laparoscopic technique.[1] Several years later, with the development of nomograms that could accurately stratify the risk for positive nodal disease, surgeons learned that patients with prostate-specific antigen (PSA) values lower than 10 and Gleason scores of lower than 7 had a very low chance of having positive nodes. This led some surgeons to question the importance of the LPLND in patients with low-risk disease.[2] There has been a dichotomy in prostate cancer surgery. One faction of surgeons recommends performing more aggressive and wider node dissections,[3,4] while another faction believes that there is insufficient evidence of a survival benefit to justify an LPLND in low-risk patients.[2]

INDICATIONS AND CONTRAINDICATIONS

Patients who might benefit from LPLND include those at high risk for metastases who are trying to decide among local therapy alone (radiation therapy, cryotherapy, or perineal prostatectomy), systemic therapy (hormonal therapy), and multimodal therapy. Surgeons who might consider aborting radical prostatectomy in the setting of nodal involvement by prostate cancer can perform LPLND at a separate setting and avoid the morbidity of prostatectomy if nodal disease is found. Noninvasive imaging techniques including computed tomography (CT) and magnetic resonance imaging (MRI) are limited in their ability to accurately determine pelvic lymph node status in patients with prostate cancer, with sensitivities as low as 17%.[5] Although there is some agreement that staging LPLND should be performed in those at high risk for nodal metastases, there is no consensus on the standard criteria that describe the high-risk patient. Factors that may indicate increased risk for positive nodes include preoperative PSA greater than 10 to 20, Gleason score of ≥7, stage 2b or higher disease, positive seminal vesicle biopsy, or enlargement of pelvic lymph nodes on imaging studies.

LPLND can also be performed in conjunction with laparoscopic radical prostatectomy based on preoperative risk factors. Other indications include staging after failed radiation treatment before salvage therapy, LPLND in conjunction with laparoscopic cystectomy for bladder cancer, and, in rare instances, suspected metastatic urethral or penile cancer.

Absolute contraindications to LPLND include bleeding diathesis, active infection, and severe coronary artery disease. Relative contraindications to LPLND are often related to surgeon experience. These may include extensive prior surgery in the lower abdomen and pelvis (inguinal hernia repair with mesh), morbid obesity, iliac artery tortuosity or aneurysm, history of inflammatory bowel disorders (extensive diverticulitis, perforated appendicitis, and inflammatory bowel disease), and patients with prior radiation in the field.

PATIENT PREOPERATIVE EVALUATION AND PREPARATION

Before LPLND, it is important to exclude metastatic disease to other sites. Studies that might be performed include chest radiography, nuclear bone scan, and CT, MRI, or ProstaScint scanning of the abdomen and pelvis. Additional tests routinely performed to assess adequacy for surgery include recent PSA level, complete blood count, serum electrolytes, standard coagulation studies, and urine culture. The patient prepares for surgery by discontinuing all aspirin, nonsteroidal anti-inflammatory medications, and other anticoagulants for appropriate periods of time. The patient eats and drinks nothing after midnight the evening before surgery and receives a perioperative intravenous antibiotic such as cefazolin. If simultaneous laparoscopic prostatectomy is to be accomplished, add gram-negative coverage. Optional preoperative preparation may include clear liquids the day before surgery and a mechanical bowel preparation to decompress the bowel the evening before surgery. A bowel preparation may be more important in patients with prior surgery or a history of inflammatory conditions of the bowel.

OPERATING ROOM CONFIGURATION AND PATIENT POSITIONING

The steps for LPLND are similar whether this procedure is performed as the initial portion of a laparoscopic radical prostatectomy or as a separate staging operation such as before definitive radiation therapy for prostate cancer.

Place the patient in the supine position with a full egg crate mattress placed underneath. Place the legs on spreader bars or in low lithotomy and place the video tower between the patient's legs close to the surgeon. Apply sequential compression devices and compressive stockings (Fig. 20–1).

Because the dissection will proceed along the large iliac vessels, the anesthesiologist is instructed to insert two large-bore intravenous lines. Nitrous oxide is avoided. Place a Foley catheter and orogastric tube to decompress the bladder and

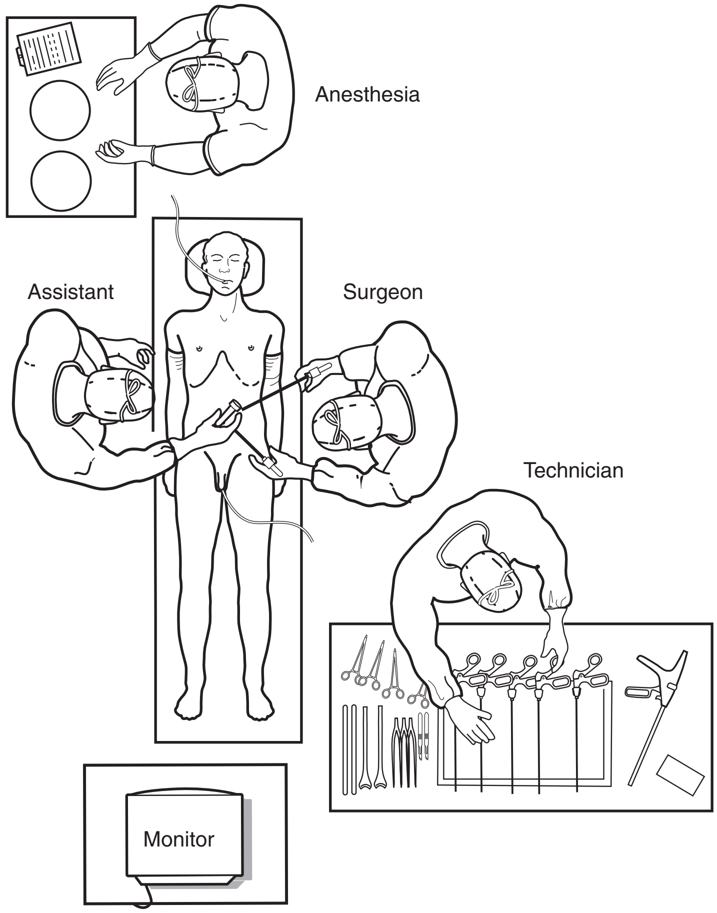


FIGURE 20–1. The operating room setup for a right-sided dissection is shown. The patient is placed in the supine position. An orogastric tube is placed. The arms are placed at the patient's side and secured with the underlying sheet. The chest and pelvis are secured with wide tape and a mid-thigh safety strap is used to secure the patient. The surgeon stands on the side contralateral to the node dissection, and the assistant usually stands on the side of the node dissection. A bladder catheter is placed after the patient is prepped and draped. A single video monitor is placed at the foot of the table. After trocar placement, the entire table is rotated 30 degrees toward the surgeon and approximately 30 degrees Trendelenburg, or head-down, position.

stomach. Tuck the arms at the patient's side in an anatomic position with the elbows slightly flexed and the thumbs pointed toward the ceiling. Stand at the patient's left side and the assistant stands at the patient's right side.

TROCAR PLACEMENT

The procedure begins with entry into the abdomen at the umbilicus using either a Veress or Hasson technique and insufflation with CO_2 gas to 15 mm Hg. Place a 10/12-mm port at the umbilicus to allow insertion of the 10-mm 30-degree lens. View the inferior epigastric vessels on the anterior abdominal wall and the location of the iliac vessels to avoid injuring these structures during additional port insertion. We routinely use the U configuration and place a 10/12-mm port on the patient's right side 8 to 9 cm lateral and 2 to 3 cm caudal to the umbilical port. Depending on the patient's anatomy, bring this port into the abdomen just medial to the inferior epigastric vessels and just lateral to the medial umbilical ligament. Place a 5-mm port on the left side in a mirror image, and place two additional ports slightly lateral and caudal for retraction and suction (one on each side). Alternatively, use a four-port diamond configuration with two midline 10/12-mm ports, one at the umbilicus and the other 4 to 6 cm superior to the pubic symphysis, and use two 5-mm ports midway between the umbilicus and the anterior superior iliac spine on either side (Fig. 20–2). Place the patient into a steep Trendelenburg position to allow gravity to retract the bowels out of the pelvis and into the abdominal cavity for better exposure. In thin patients, the location of the iliac vessels can be seen, whereas in obese patients, it may be necessary to use an instrument to palpate the pulsations of the external iliac artery. Frequently, on the left side, sigmoid adhesions may need to be taken down to allow exposure to the obturator fossa.

PROCEDURE

Before beginning the node dissection on the right side, roll the table approximately 30 degrees to the left to facilitate improved ergonomics and access to the right nodal packet behind the iliac vessels. Familiarity with the relevant evident and hidden surgical anatomy facilitates surgical dissection and delineation of the node packet (Fig. 20–3). Identify the important anatomic landmarks, including the medial umbilical ligament and the internal inguinal ring with the vas deferens emanating from it. Note the location of the bladder, rectum, and iliac vessels. In some thin patients, the course of the ureter can be identified (Fig. 20–4). If the ports have been placed appropriately, it is easier to delineate the anatomic boundaries and to perform the subsequent dissection (Fig. 20–5).

The procedure starts by incising the peritoneum just lateral to the medial umbilical ligament just over the external iliac vein. Open the peritoneum in a cephalad and medial direction, following the lateral surface of the medial umbilical ligament as it extends cephalad and becomes the obliterated umbilical artery. Extend the peritoneal incision from the level of the

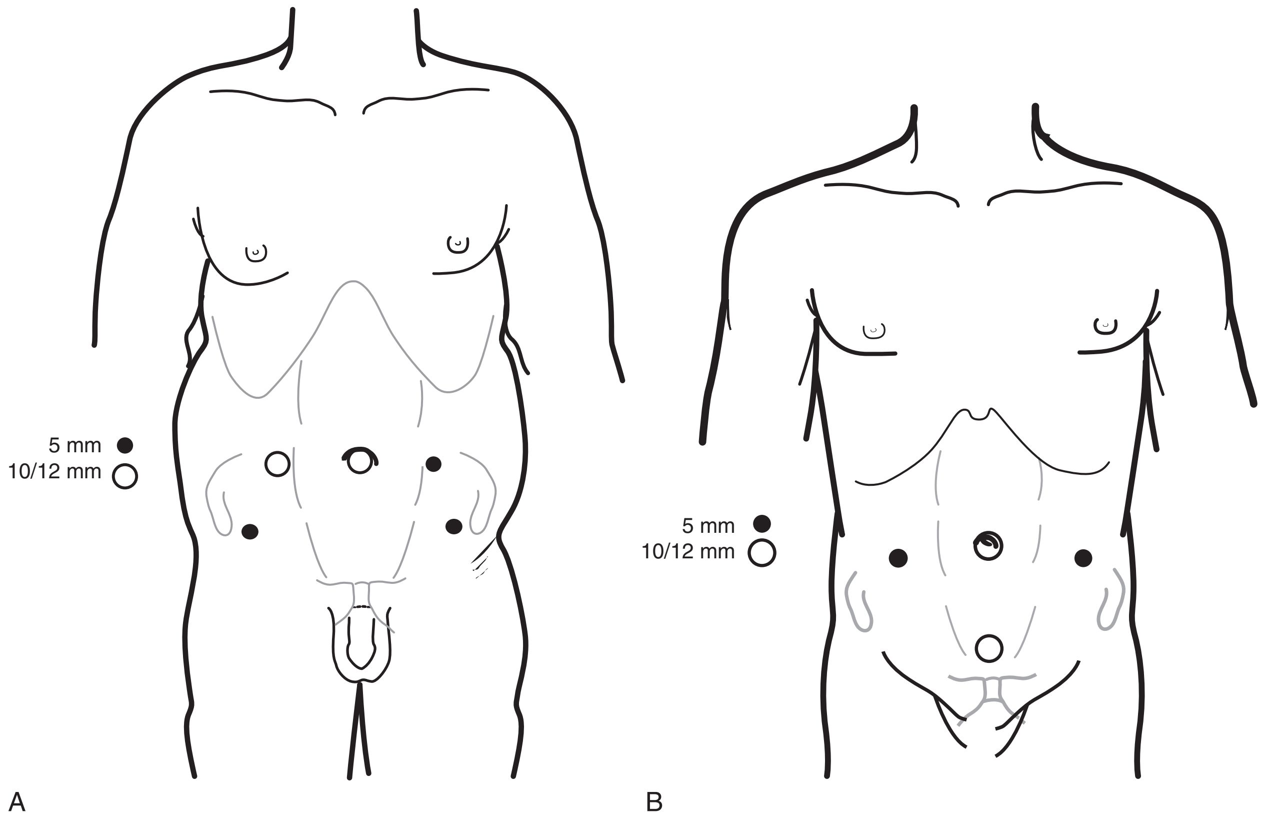


FIGURE 20–2. Port placement. *A,* In the U configuration, five trocars are used. A 10/12-mm trocar is initially placed at the umbilicus and acts as the camera port. An additional 10/12-mm port is placed on the patient's right side 8 to 9 cm lateral and 2 to 3 cm caudal to the umbilical port. A 5-mm port is placed on the left side in a mirror image, and two additional 5-mm ports are placed slightly lateral and caudal for retraction and suction. *B,* In the "diamond" configuration, two midline 10/12-mm ports are used, one at the umbilicus and the other 4 to 6 cm superior to the pubic symphysis. Two 5-mm ports are placed on either side midway between the umbilicus and the anterior superior iliac spine.

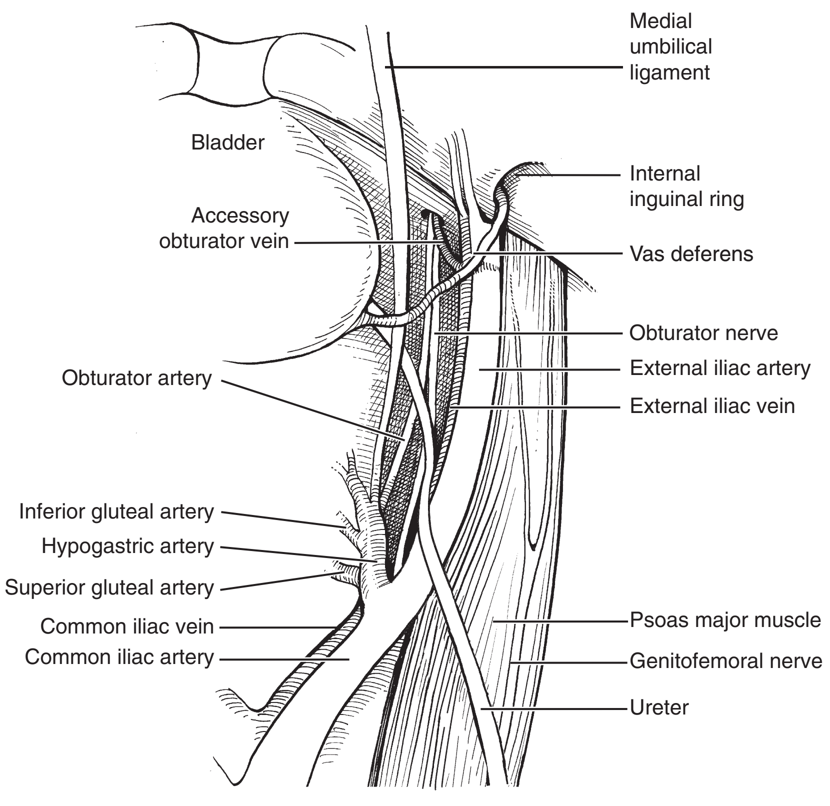


FIGURE 20–3. Important laparoscopic anatomic landmarks visualized on entering the peritoneal cavity—the medial umbilical ligament can be seen, along with the vas deferens and spermatic vessels emanating from the internal inguinal ring. The peritoneal line of incision is made just lateral to the medial umbilical ligament paralleling the iliac vein.

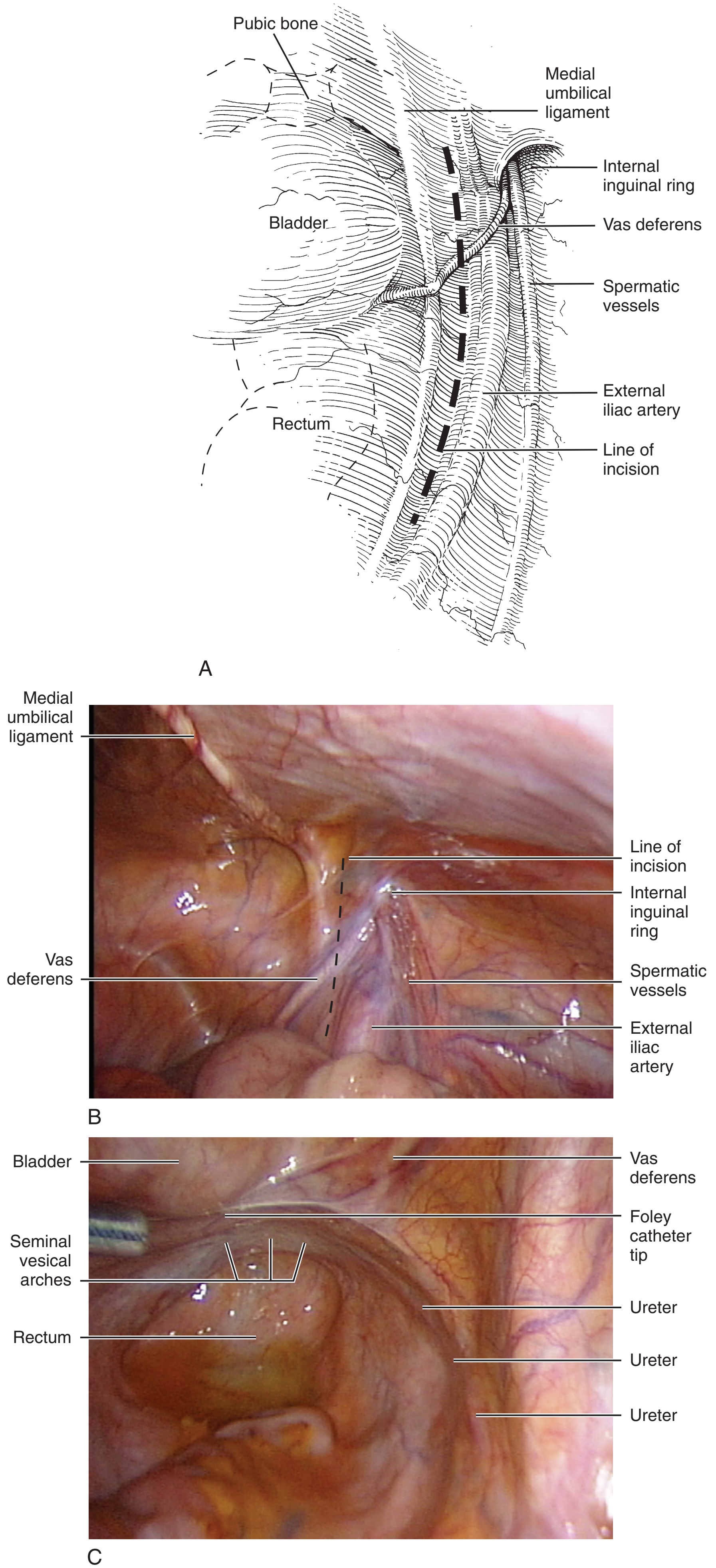


FIGURE 20–4. *A,* Other important landmarks for anatomic orientation are shown here. *B,* An actual image taken from a patient prior to dissection helps demonstrate the important landmarks. *C,* The bladder with Foley catheter tip, rectum, seminal vesical arches, and iliac vessels can be identified. In some thin patients, the course of the ureter can be seen.

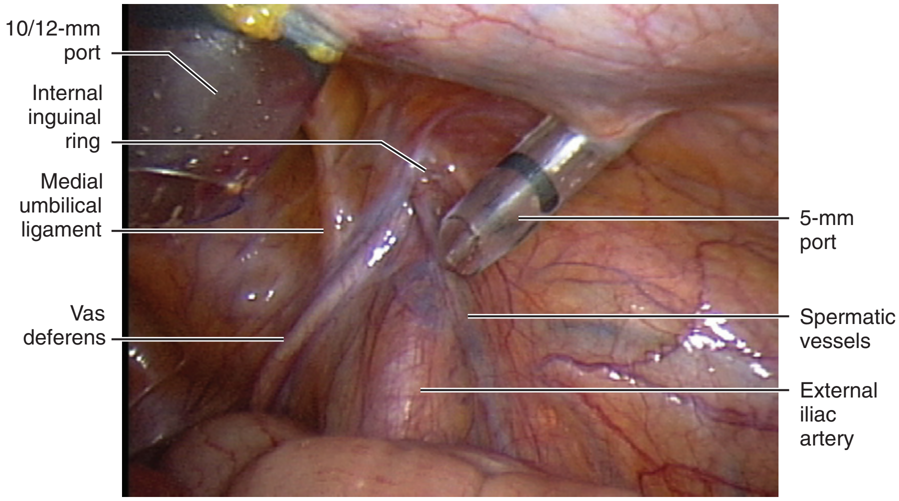


FIGURE 20–5. Demonstration of the anatomic landmarks relative to port placement.

inguinal ring cephalad to 1 to 2 cm above the bifurcation of the iliac vessels. Gently grasp the medial umbilical ligament and manipulate it back and forth to identify where to open the peritoneum. Next, identify the external iliac vein. In some patients, the vein can be seen and directly dissected, whereas in other patients, the vein cannot be seen. In the latter instance, identify the pulsations of the external iliac artery and carry the dissection down along the medial surface of the artery until the vein is encountered. Due to the compressive effects of the pneumoperitoneum, the vein often appears flattened during laparoscopic surgery. If necessary, to help delineate the margins of the external iliac vein, temporarily decrease the pneumoperitoneum to 5 mm Hg to allow the vein to fill with blood. Using a hook electrode or harmonic scalpel, continue the dissection cephalad along the iliac vein until the entire anterior surface has been exposed. Dissect the vein from just proximal to where it crosses under the inguinal ligament cephalad to 1 cm above the junction with the common iliac vessels to complete the lateral boundary of the conventional LPLND (Fig. 20–6).

Next, develop the medial border of the node packet. Using the medial umbilical ligament as a landmark and following it proximally helps to delineate the medial boundary of the nodal packet while avoiding inadvertent injury to the bladder. Much of this dissection can be done bluntly, although occasional judicious use of electrocautery helps delineate the medial boundary of the nodal packet. This medial boundary is also developed from the pubic bone cephalad to the area of the iliac bifurcation (Fig. 20–7).

After establishing the lateral and medial boundaries of the node packet, deepen these boundaries in the posterior plane. Transect the vas deferens between clips to facilitate this dissection. Precise use of the hook electrode to elevate the tissue away from the medial aspect of the vein before cauterization facilitates separation of the nodal packet. Posteriorly dissect the medial surface of the external iliac vein until the muscular pelvic side wall is encountered. Gently retract laterally on the iliac vein with the tip of the suction device through the most lateral 5-mm port to allow for better exposure of the pelvic side wall. Continue the dissection posteriorly in a plane along the pelvic side wall for 2 to 3 cm to complete the deepening of the lateral boundary of the node dissection. Hugging the side wall ensures that all nodal tissue is removed and prevents injury to the obturator vessels and nerve. Extend the lateral boundary caudally until the pubic bone is encountered. At this level, place a 10-mm right angle around the nodal packet.

With gentle spreading just caudal to the node of Cloquet, dissect enough of the lymphatic pedicle to allow placement of clips in order to secure the distal nodal packet. Then transect the lymphatic pedicle between the clips. Continue the dissection posteriorly until the obturator nerve is encountered. Take the nodal tissue on either side of the obturator nerve, thus skeletonizing the obturator nerve and vessels. Transection of the nodal packet on the pubic bone establishes the caudal apex of the node packet and skeletonizing the obturator nerve and vessels identifies the posterior boundary. Once the deep margin of the nodal packet has been identified, extend this plane of dissection cephalad until the bifurcation of the iliac vessels is encountered. While extending the dissection in this direction, remain vigilant to avoid inadvertent injury to an accessory obturator vein. If an accessory obturator vein is identified, transect between clips to simplify removal of the node packet. This vein may be very distal, close to the pubic bone, but has a variable location that may include anywhere between the iliac bifurcation and the inguinal ligament (Fig. 20–8). During this dissection, the assistant can provide suction and retraction through the right lateral 5-mm port site while the surgeon grasps the distal node packet and moves the packet laterally and medially to facilitate removal of all nodal tissue without injury to the obturator nerve.

At the cephalad extent of the node packet, take care to retract the ureter and periureteral tissues medially to avoid thermal injury to the ureteral blood supply. The cephalad extent of the node packet is transected at the level of the bifurcation of the iliac vessels. To secure the proximal nodal packet, routinely apply clips to secure large lymphatics. In patients with small lymphatics, these may alternatively be sealed with the harmonic scalpel or electrocautery. Perform careful inspection of the obturator fossa to ensure that all nodal tissue has been removed (see Fig. 20–8*E*).

After completely freeing the nodal packet, place it into a 10-mm endoscopic retrieval bag. Following closure of the bag, place the specimen into the pelvis and lower the pneumoperitoneum to less than 5 mm Hg in order to check for any venous bleeding or lymphatic leak. Control any bleeding or lymphatic leak before proceeding to the contralateral node dissection.

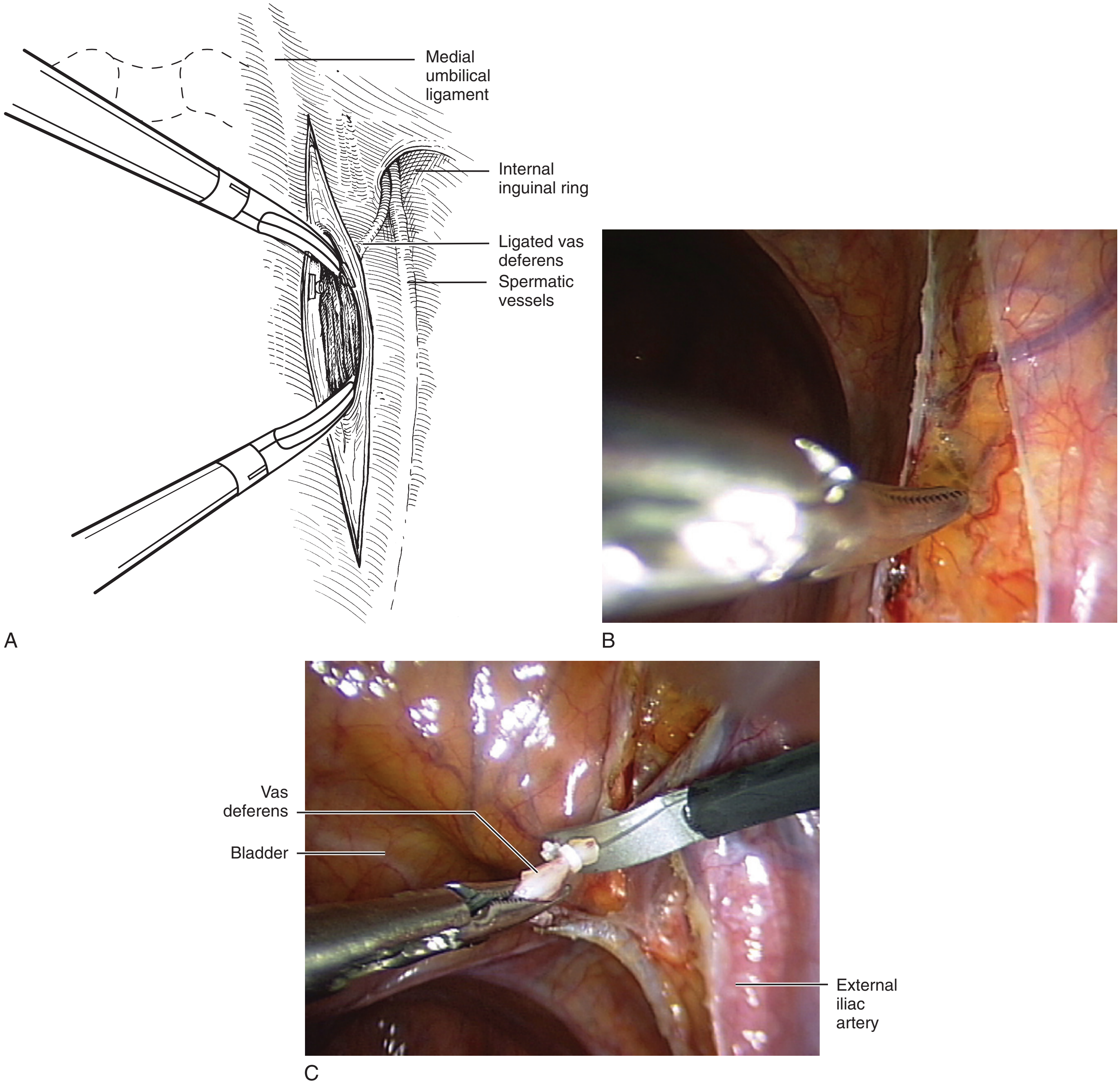
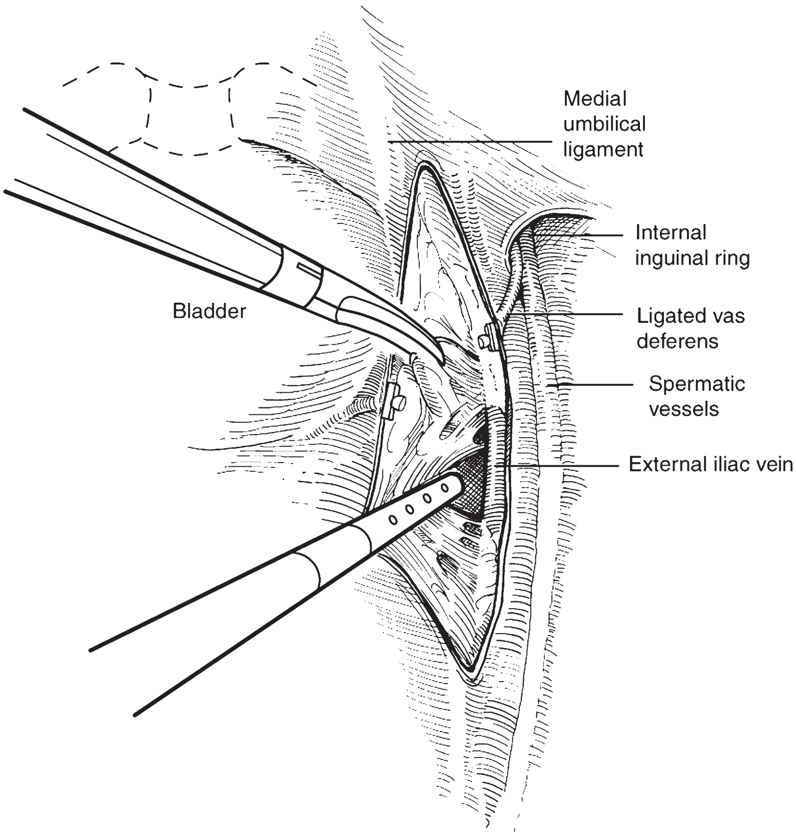


FIGURE 20–6. *A,* The dissection begins by incising the peritoneum just lateral to the medial umbilical ligament. *B,* The peritoneal edges are lifted up, revealing the underlying nodal packet. *C,* Transection of the vas deferens between clips is usually recommended to facilitate access to the nodal packet.

Remove the nodes through a 10/12-mm port, or, alternatively, remove bulky nodes along with the port at the conclusion of the procedure.

After completing the right-sided node dissection, rotate the patient to the opposite side before proceeding with the contralateral dissection. Perform the left-sided dissection in an identical but mirror-image fashion. Following completion of both node dissections, desufflate the abdomen to check for bleeding. Remove both node packets and the entrapment sacs into which they have been placed. Bring in a closed suction drain through a 10/12-mm port, and bring out the external end of the drain through one of the 5-mm extreme lateral port sites. Close the 10/12-mm port sites using a Carter-Thomason CloseSure system (Inlet Medical, Eden Prairie, MN). Inspect all port sites at low abdominal pressure before exit from the abdomen to ensure complete hemostasis. Inject the port sites with 0.25% bupivacaine (Marcaine) at the level of the fascia and dermis and close the skin with a 4-0 monofilament absorbable suture. Apply benzoin and Steri-Strips, or use Dermabond (Ethicon, Somerville, NJ) to cover the incisions.



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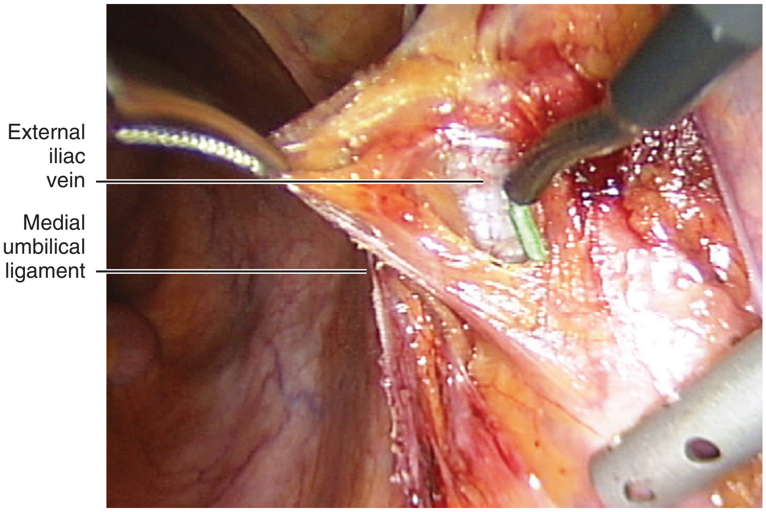


B

FIGURE 20–7. *A,* Gentle traction is used on the nodal packet and blunt dissection with the tip of the irrigator aspirator serially elevates tissue away from the external iliac vein to expose the anterior surface. *B,* The hook electrode can be used to divide attachments, small blood vessels, and small lymphatic channels. This plane of dissection is followed until the muscles of the pelvic side wall are encountered.

In some settings (bladder, urethral, penile, and prostate cancer), an extended lymph node dissection to incorporate the common, internal, and external iliac lymph nodes as well might be performed.[6] Proceed in a manner similar to conventional node dissection, except the lateral border of dissection is along the common iliac artery up to the genitofemoral nerve. The medial extent of dissection is the medial border of the bladder and ureter. The dissection caudally remains the same as the modified or standard lymph node dissection, but cranially the dissection is carried above the common iliac artery bifurcation.

POSTOPERATIVE MANAGEMENT

Postoperatively, patient management is dictated by the additional procedures that are performed at the time of node dissection. Patients undergoing a node dissection only are routinely discharged on the day following surgery after showing that they can tolerate a regular diet. In patients undergoing additional simultaneous procedures such as laparoscopic radical prostatectomy, the postoperative course is determined by the additional

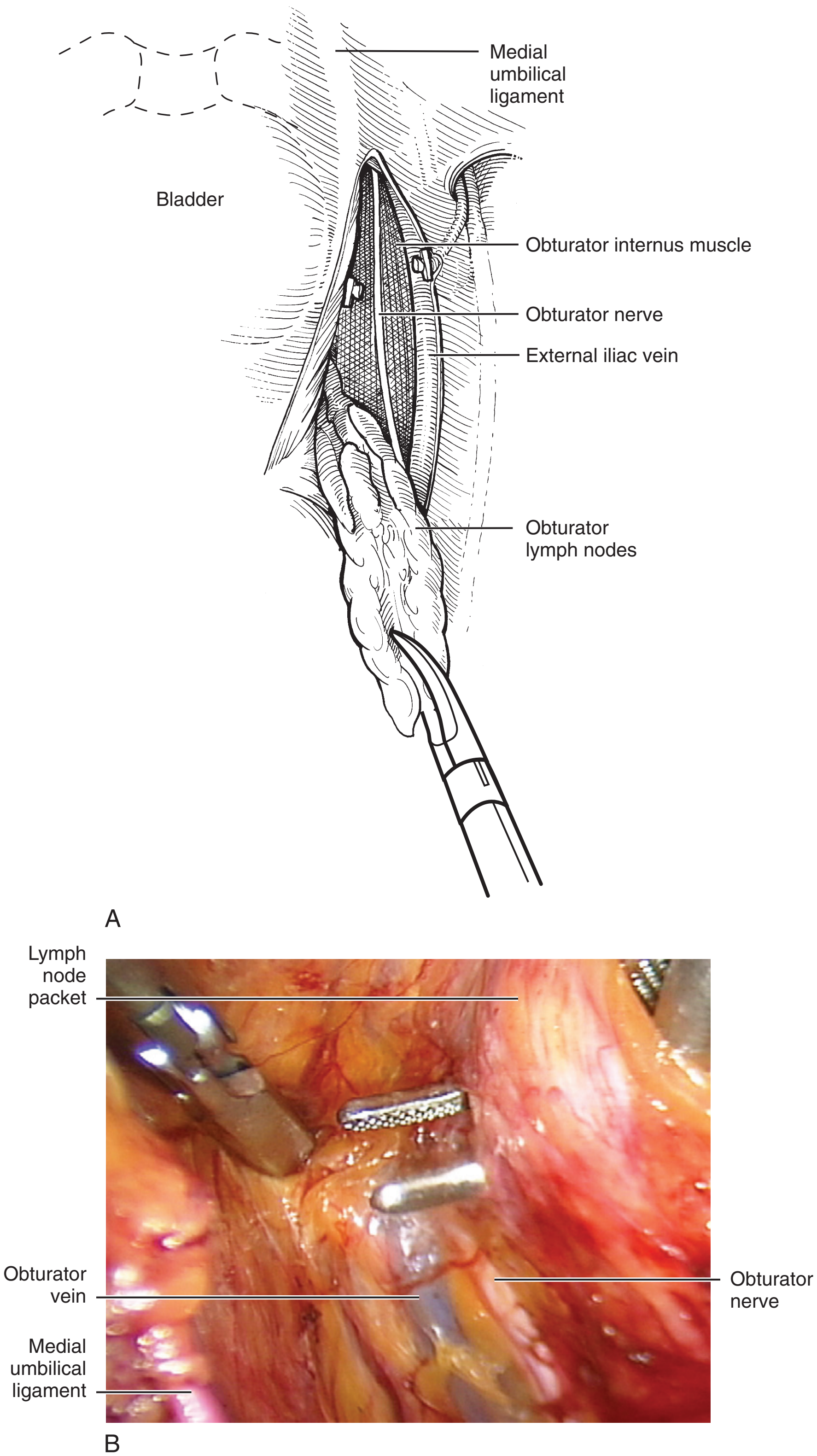
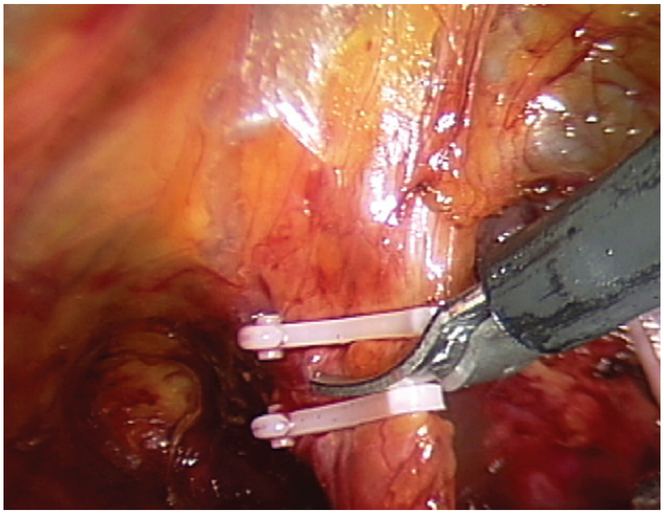


FIGURE 20–8. *A,* The lateral boundary of the node dissection is extended caudally until the pubic bone is reached. At this level, a 10-mm right angle is placed around the nodal packet just caudal to the node of Cloquet. *B,* After securing the distal lymphatic pedicle between clips, it is then transected with scissors.

Continued



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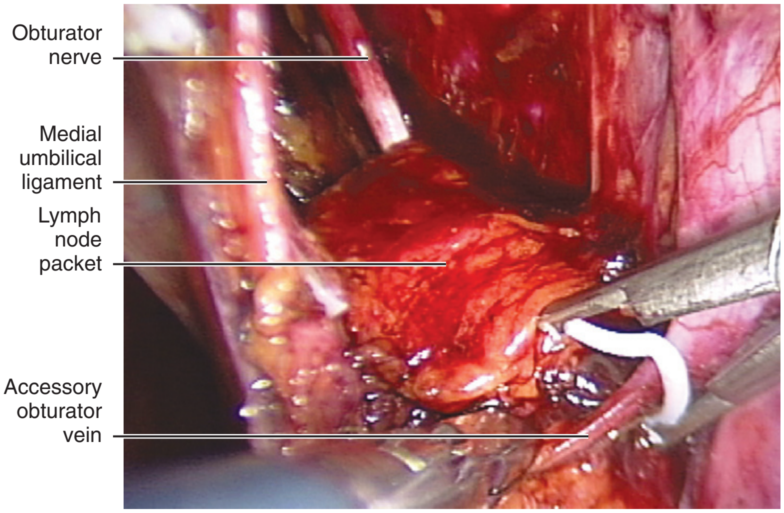

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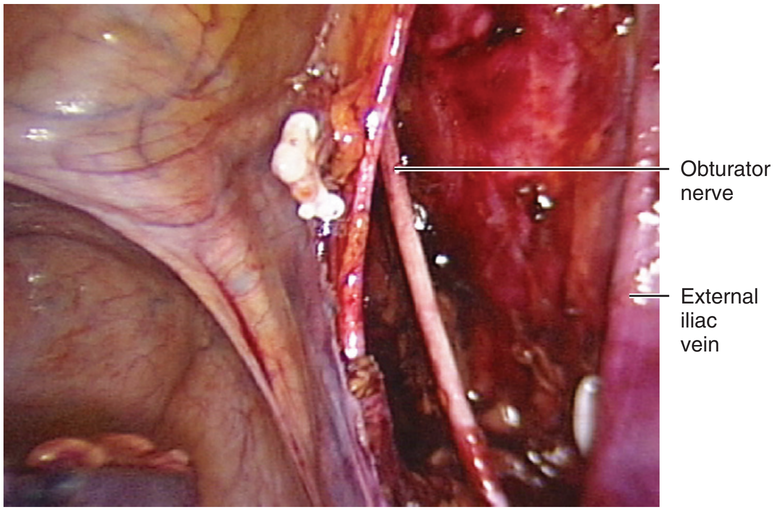

E

FIGURE 20–8, cont'd. *C,* During dissection of the nodal packet, an accessory obturator vein is often identified joining the medial side of the external iliac vein. Transection between clips simplifies removal of the node packet. *D,* The cephalad extent of the node packet is transected at the level of the bifurcation of the iliac vessels. *E,* Careful inspection of the obturator fossa ensures that all nodal tissue has been removed and that there is adequate hemostasis.

procedures that are performed. Early ambulation is important to minimize the morbidity of surgery.

COMPLICATIONS

Intraoperative complications may include vascular and viscus injuries. The most common vascular injuries include injury to the epigastric artery, medial umbilical ligament, and accessory obturator vein but may also include the external iliac vessels and their tributaries. Viscus injuries include those to the ureters, bowel, and bladder. Take care to avoid injury to the obturator nerve. The incidence of all types of complications decreases with the increased experience of the operating surgeon and the surgeon's familiarity with the anatomy. Repair bladder and bowel injuries using intracorporeal techniques or open conversion, if necessary. Major injury to the iliac vessels should prompt vascular surgical consultation.

Postoperative complications may include hematomas, lymphocele, wound infection, ileus, small bowel obstruction, urinary retention, obturator nerve palsy, and deep venous thrombosis of the lower extremity.[8] To prevent deep venous thrombosis, administer prophylactic subcutaneous heparin or enoxaparin for 5 days beginning on postoperative day 1, and use sequential compression devices intraoperatively and postoperatively, if desired. Lymphocele is rare when a transperitoneal approach is used but is more common with an extraperitoneal approach. If a large lymphocele develops, perform drainage to avoid the increased risk of deep venous thrombosis.

SUMMARY

In conclusion, LPLND remains an important staging tool in the treatment of prostate cancer. With experience, this procedure can be performed with minimal morbidity and a low incidence of complications. Long-term studies will be necessary to define the potential curative effect of the node dissection for prostate cancer.

Tips and Tricks

- Sometimes the external iliac vein cannot be identified. Due to the compressive effects of the pneumoperitoneum the vein often appears flattened during laparoscopic surgery. The pneumoperitoneum can be temporarily decreased to 5 mm Hg to allow the vein to fill with blood in order to delineate the margins.
- If the internal inguinal ring cannot be identified, scrotal traction should move the spermatic cord and identify its entrance into the ring.
- On insertion of the laparoscopic port in the area of the inferior epigastric artery, significant bleeding may be encountered. Use the Carter-Thomasen CloseSure system to place a suture medial and lateral to the bleeding inferior epigastric vessel above and below the area of bleeding. These can be pulled tightly with a clamp during the surgery and then tied down onto the epigastric vessels after the completion of the procedure.
- If the Foley bag becomes distended like a balloon, suspect bladder injury due to dissection medial to the medial umbilical ligament. Identify bladder injury and repair with intracorporeal laparoscopic suturing techniques.
- There may be difficulty identifying medial boundary of nodal dissection. In this situation, firmly grasp the medial umbilical ligament with a grasping device and move it back and forth to delineate the obliterated umbilical artery. Use this as a starting point to begin blunt dissection to identify the medial edge of lymph node packet.

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CHAPTER 21

Laparoscopic Retroperitoneal Lymph Node Dissection

Mohamad E. Allaf

As many as 70% of men with clinical stage I nonseminomatous germ cell tumors (NSGCTs) undergo open retroperitoneal lymph node dissection (RPLND) or chemotherapy unnecessarily; thus, a minimally invasive approach to stage the retroperitoneum is attractive. Initial series of laparoscopic RPLND served this purpose and helped delineate those who have metastases and require chemotherapy versus those who can be observed safely. Because the probability of nodal disease posterior to the great vessels is minimal in the absence of anterior metastases, most series omitted the retrocaval and retroaortic dissections, and all patients found to have pathologic stage II disease received chemotherapy.[1]

Advances in instrumentation, the advent of hemostatic agents, and increased experience with laparoscopy within urology allowed the evolution of laparoscopic RPLND from a staging operation to a therapeutic one that fully duplicates the open technique. Retrocaval and retroaortic lymph nodes are now routinely excised in experienced centers, and chemotherapy is omitted for men harboring limited metastases.[2]

INDICATIONS AND CONTRAINDICATIONS

Approximately 30% of men with NSGCT with no radiographic evidence of lymph node metastases harbor occult nodal involvement at RPLND. Factors in the orchiectomy specimen predictive of occult lymph node involvement include lymphovascular involvement, percentage of embryonal component, and invasion of the rete testis or tunica albuginea.[3] The ideal candidate for laparoscopic RPLND has clinical stage I NSGCT (negative serum markers) and is at high risk of occult retroperitoneal disease. Patients at low risk for metastatic disease may also undergo laparoscopic RPLND, depending on their desires, especially if they are poor candidates for surveillance. A residual mass following chemotherapy in the setting of negative serum markers is another indication. These cases can be especially difficult due to the desmoplastic tissue reaction resulting from chemotherapy. Laparoscopic RPLND may also play a role in patients with gynecologic malignancy (cervical, endometrial, or ovarian) in specific circumstances.

Contraindications to laparoscopic RPLND are similar to those for the open approach. Patients with known bulky metastases and elevated tumor markers are typically not candidates for this approach. Prior abdominal surgery, previous peritonitis, and morbid obesity are not absolute contraindications, but these patients must be approached with great caution. Postchemotherapy laparoscopic RPLND (just like open RPLND), as mentioned previously, is technically challenging due to the obliteration of surgical planes and is associated with a higher probability of complications and open conversion.[4]

PATIENT PREOPERATIVE EVALUATION AND PREPARATION

All candidates for laparoscopic RPLND must have undergone a recent metastatic evaluation that, at minimum, includes a physical examination, serum tumor markers (lactate dehydrogenase, α-fetoprotein, and human chorionic gonadotropin), and a computed tomography (CT) scan of the chest, abdomen, and pelvis. Offer the patient the option to bank sperm preoperatively. Counsel all patients regarding the risks and benefits of the procedure and the possibility of open conversion. In the postchemotherapy setting, it is imperative to allow normalization of hematological parameters (white blood cells and platelets) and to optimize pulmonary function in patients who have received bleomycin.

Patients are given a mechanical bowel preparation the day before surgery to decompress the bowel. An enema may also be administered to cleanse the colon. Patients receive a first-generation cephalosporin such as cefazolin in the preoperative area. Thromboembolic deterrent stockings and sequential compression devices are placed on the lower extremities. An active type and screen must be available on all patients.

PATIENT POSITION AND OPERATING ROOM CONFIGURATION

After the induction of general anesthesia, place the patient in the supine position, pad the arms, and secure the arms to the patient's sides. Secure the patient's arms, chest, and hips to the table with wide cloth tape, allowing maximal rotation of the table during the procedure (Fig. 21–1). Perform a bilateral dissection, if needed, with this positioning scheme. Insert an orogastric tube and a Foley catheter before insufflation.

The surgeon and assistant stand on the side contralateral to the tumor, with the scrub nurse standing on the ipsilateral side. The surgeon is free to move to the other side during a bilateral dissection. Two monitors are used so that all members of the surgical team can observe the procedure (Fig. 21–2). A laparotomy set, including vascular clamps and retractors, is available for immediate access if needed.

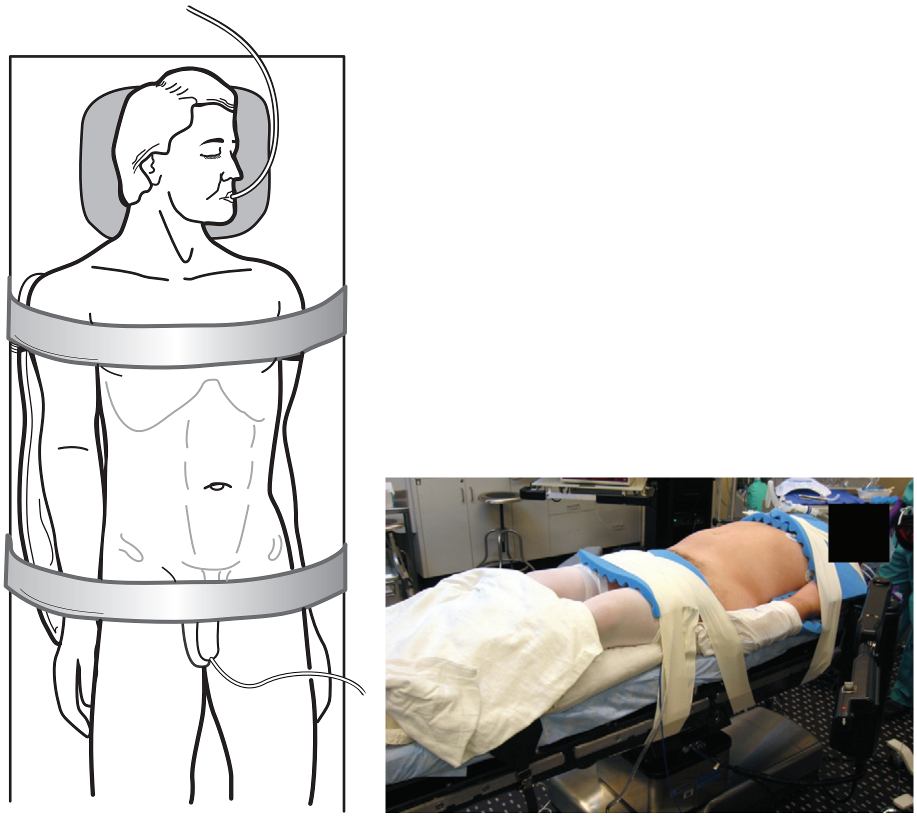


FIGURE 21–1. *A* and *B*, The patient is placed in the supine position with the arms adducted and pressure points padded. Wide cloth tape is used to secure the patient to the table.

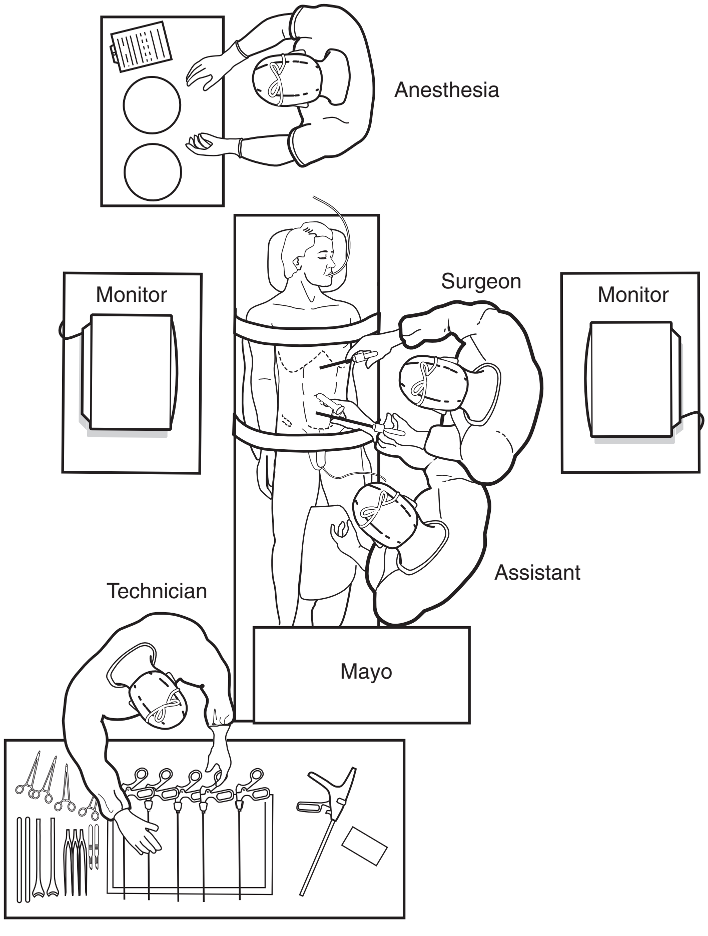


FIGURE 21–2. The surgeon stands on the side contralateral to the tumor. Two monitors are used so that all members of the team can observe the procedure. A laparotomy set is open and available for rapid access as needed to control severe bleeding.

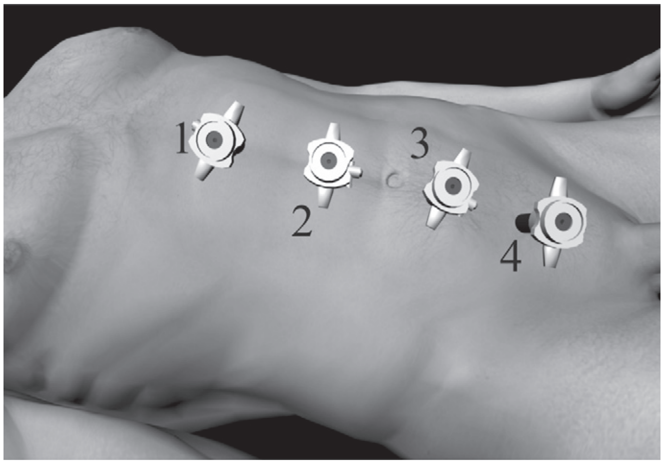


FIGURE 21–3. Four equally spaced (10/12-mm) laparoscopic ports are placed in the midline beginning 2 to 4 cm inferior to the xyphoid process. It is not necessary that the umbilicus be incorporated as a port site.

TROCAR PLACEMENT

Introduce a Veress needle at the base of the umbilicus, and establish the pneumoperitoneum. Use a pressure of 15 to 20 mm Hg throughout the procedure. Establish initial port access under direct vision using a 0-degree lens inserted into an optical trocar (Visiport; U.S. Surgical, Norwalk, CT). Then use a 30-degree lens to visualize entry of subsequent ports and to complete the procedure. After placing the ports, rotate the bed toward the surgeon to allow bowel segments to fall away from the operative field. Use the Trendelenburg position as needed to help displace the small bowel superiorly and medially.

Place four equally spaced 10/12-mm laparoscopic ports in the midline, beginning 2 to 4 cm inferior to the xyphoid process (Fig. 21–3). The umbilicus does not necessarily need to be incorporated as a port site. This ensures that the inferior port is not placed too low and maximizes the working envelope of all the ports. The large port size is essential in order to allow for the convenient introduction of larger (10/12-mm) instruments from various angles. Place an additional 5-mm port for additional retraction in the ipsilateral mid-axillary line midway between the iliac crest and ribs if needed. The position of the camera and major working ports changes as the operation progresses. Place the camera in trocar 3 for the inferior portion of the dissection, and as the operation continues superiorly, move the camera to trocar 2. Use the adjacent trocars as working ports, and leave the remaining port available for retraction.

PROCEDURE

Template Dissection

I routinely use the modified template dissection as described by Donohue and colleagues[5] (Table 21–1, Fig. 21–4). If metastatic disease is detected intraoperatively, perform a bilateral modified template dissection, in accordance with accepted oncologic principles. Routinely excise retroaortic and retrocaval nodes, and clear the entire template area of all nodal tissues.

TABLE 21–1. TEMPLATE BORDERS FOR LAPAROSCOPIC RETROPERITONEAL LYMPH NODE DISSECTION

Border	Right Side	Left Side
Lateral	Ureter	Ureter
Medial	Preaortic node	Vena cava
Superior	Renal hilum	Renal hilum
Inferior	Origin of internal mesenteric artery, right common iliac vessels	Origin of internal mesenteric artery, left common iliac vessels

Colonic Reflection

For a left-sided tumor, incise the white line of Toldt from the level of the iliac vessels to the spleen superiorly. Incising the lienocolic ligaments allows the spleen and pancreas to roll medially. Medial traction on the colon reveals colorenal attachments that must be divided. This maneuver drops the colon medially and exposes the underlying Gerota's fascia. On the right side, extend the peritoneal incision superior to the hepatic flexure and then carry the incision medially (Fig. 21–5). Perform a Kocher maneuver to release the duodenum medially, and expose the anterior surface of the inferior vena cava (IVC) (Fig. 21–6). Medial traction on the colon reveals Gerota's fascia on this side as well. Blunt dissection and traction reveal attachments that need to be divided to ensure wide reflection of the colon.

Incising the posterior peritoneum too far laterally severs the lateral attachments of the kidney and allows it to rotate into the field of dissection, thus complicating matters. Avoid using energy sources such as electrocautery in proximity of bowel; unrecognized bowel injury due to thermal spread can have disastrous consequences. On the right side, always identify the duodenum and mobilize it medially to avoid inadvertent injury. If a buttonhole is created in the mesentery during colon reflection, identify it promptly and close it because it can cause bleeding intraoperatively and may facilitate internal hernia formation postoperatively.

Spermatic Vein Dissection

After completely reflecting the colon, follow the spermatic cord with gonadal vein toward the internal ring. Identify the ureter as the gonadal passes superiorly toward the internal ring. Identifying the ureter is important to prevent injury and as part of the limits of the dissection (Fig. 21–7).

Incise the posterior peritoneum, and identify and circumferentially dissect the orchiectomy suture (Fig. 21–8). Use a combination of traction, blunt dissection, and cautery to free the suture. The vas deferens can be ligated and divided. Take great care to avoid injury to the iliac vessels posteriorly and the inferior epigastric vessels medially. Dissect the spermatic vein and associated tissues from the inguinal ring to the IVC on the right and renal vein on the left (Figs. 21–9 and 21–10). Then ligate and transect the proximal end of the spermatic vessels. Place this specimen in an EndoCatch (U.S. Surgical) bag and remove immediately to avoid tumor seeding or loss of the specimen.

Always identify the ureter early and never skeletonize it. If the gonadal artery is encountered as the dissection proceeds

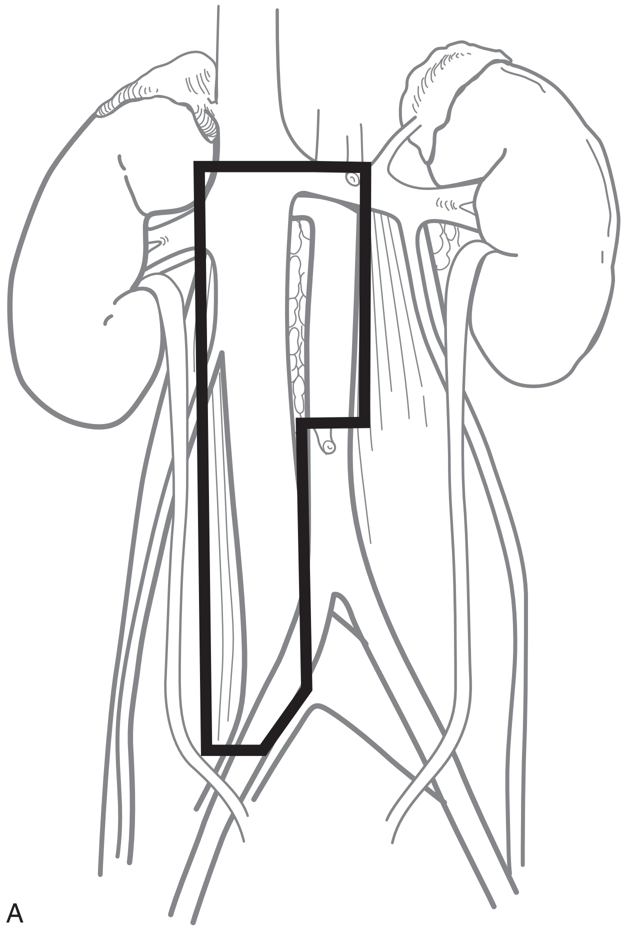


FIGURE 21–4. Limits of the laparoscopic retroperitoneal lymph node dissection on the right side *(A)* and left side *(B)*. The borders are listed in Table 21–1.

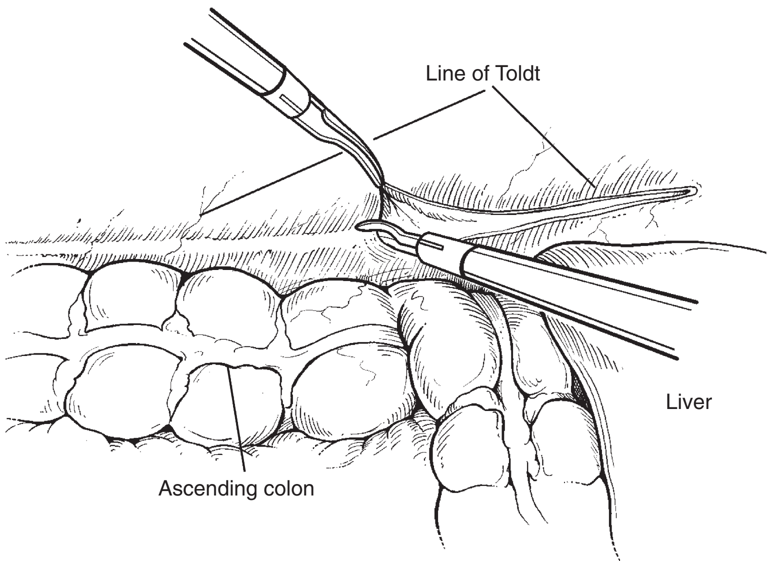


FIGURE 21–5. The colon is reflected by incising the line of Toldt from the hepatic flexure to below the iliac vessels.

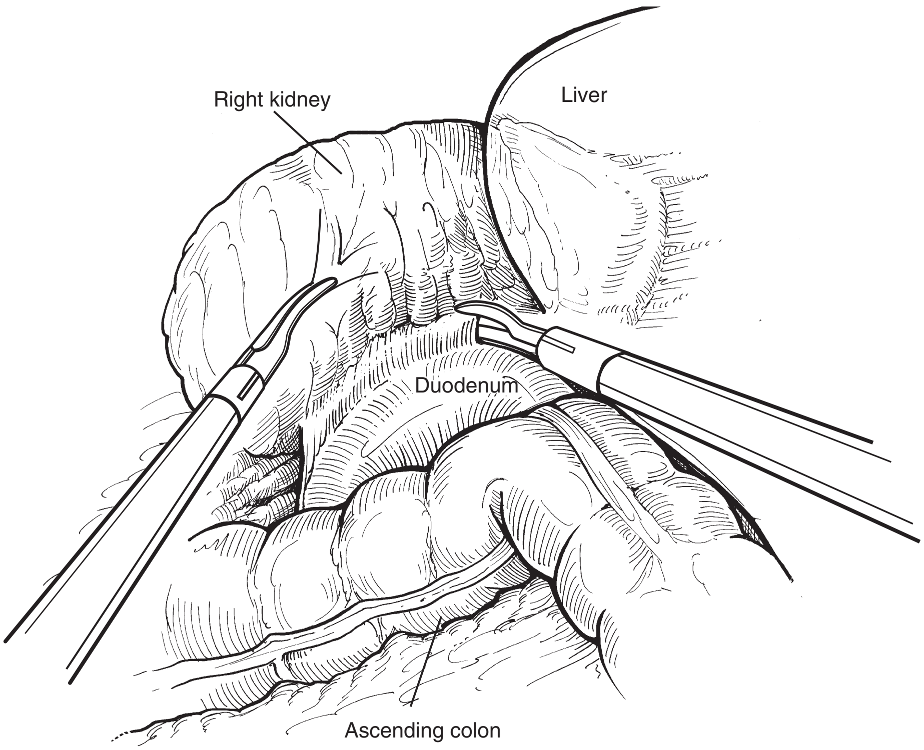


FIGURE 21–6. The duodenum is identified and a Kocher maneuver is performed with blunt and sharp dissection. The use of energy sources is minimized to avoid thermal damage to the duodenum. The inferior vena cava and renal hilum are exposed after the duodenum and colon are reflected medially.

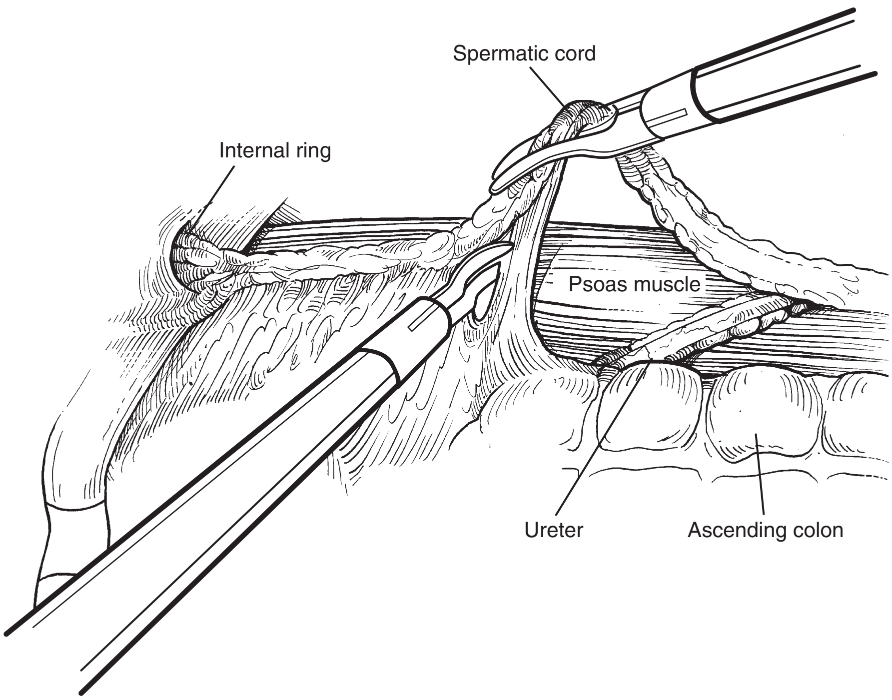
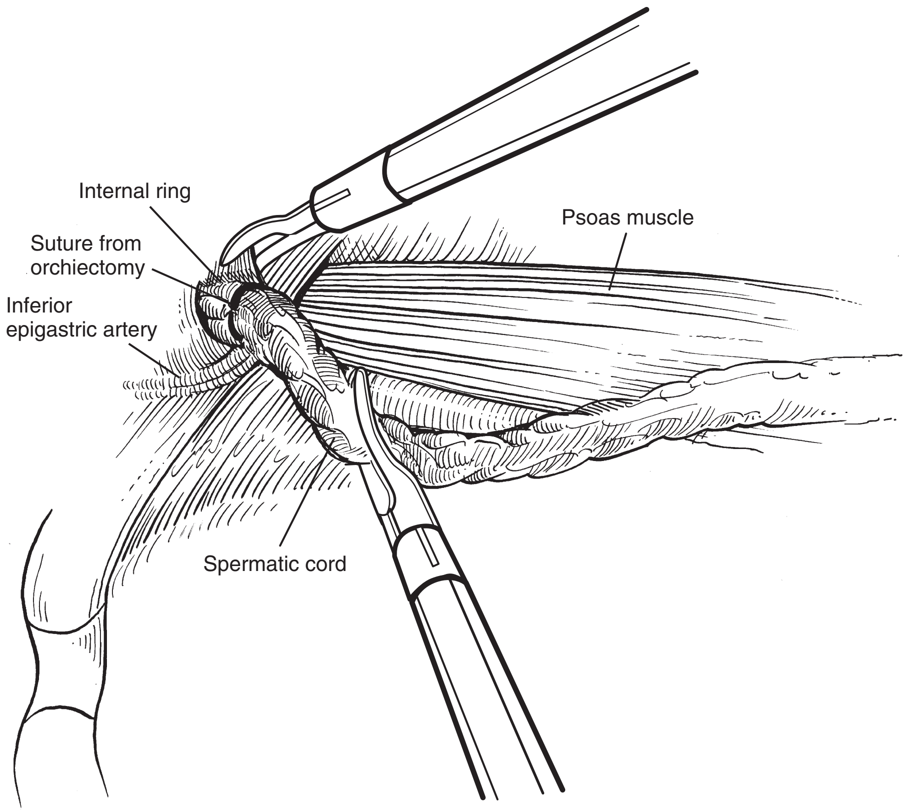
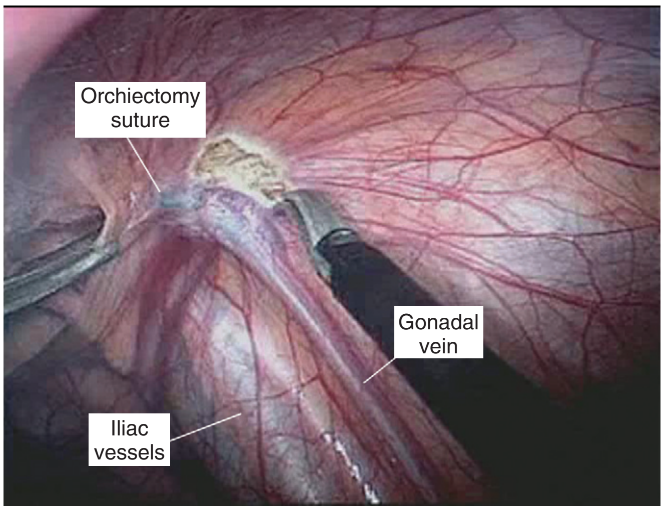


FIGURE 21–7. The ureter is identified as the gonadal vessels cross superiorly to reach the internal inguinal ring.



A



B

FIGURE 21–8. *A,* The orchiectomy suture is identified at the internal inguinal ring and electrocautery is used to incise the posterior peritoneum and circumferentially dissect the cord. *B,* The peritoneum is incised over the end of the spermatic cord at the internal inguinal ring.

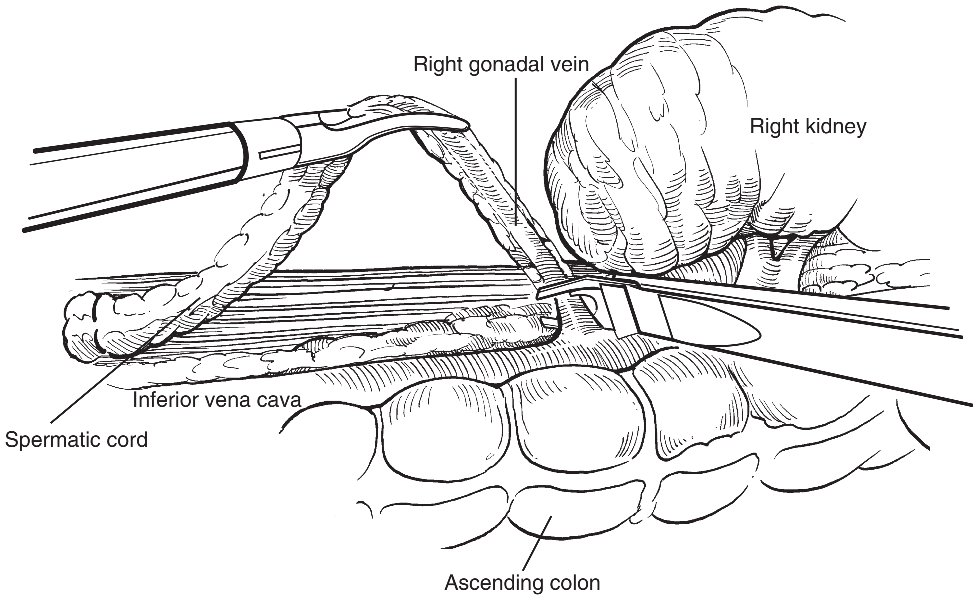


FIGURE 21–9. During a right-sided dissection, the cord is dissected to the origin of the gonadal vein at the vena cava. The vein is then clipped and divided at the level of the inferior vena cava.

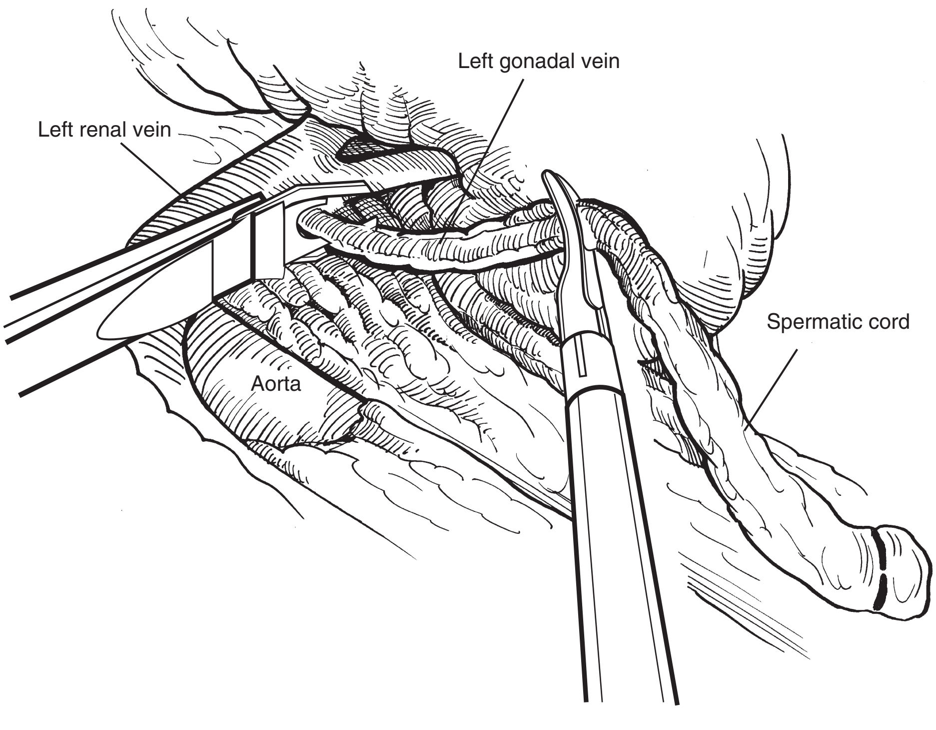


FIGURE 21–10. During a left-sided dissection, the cord is dissected to the origin of the gonadal vein at the left renal vein. The gonadal vein is then clipped and divided. The gonadal artery may be encountered and is also ligated and divided.

superiorly, ligate and divide it. If accessory lower pole renal vessels are encountered, do not injure them.

Precaval, Preaortic, and Lateral Dissection: "Split and Roll"

Gently lift the tissues overlying the great vessels and carefully score these tissues with electrocautery longitudinally (Fig. 21–11). Use blunt dissection to further aid in separating these lymphatic tissues along the length of the great vessels. This often creates a plane of dissection that can be developed laterally and helps in initiating the lateral dissection (Fig. 21–12). Although lumbar vessels can be encountered here, proceed laterally along the side wall and tackle these vessels later in the dissection. On the left side, only split the tissues to a level 5 cm inferior to the renal vein (origin of the inferior mesenteric

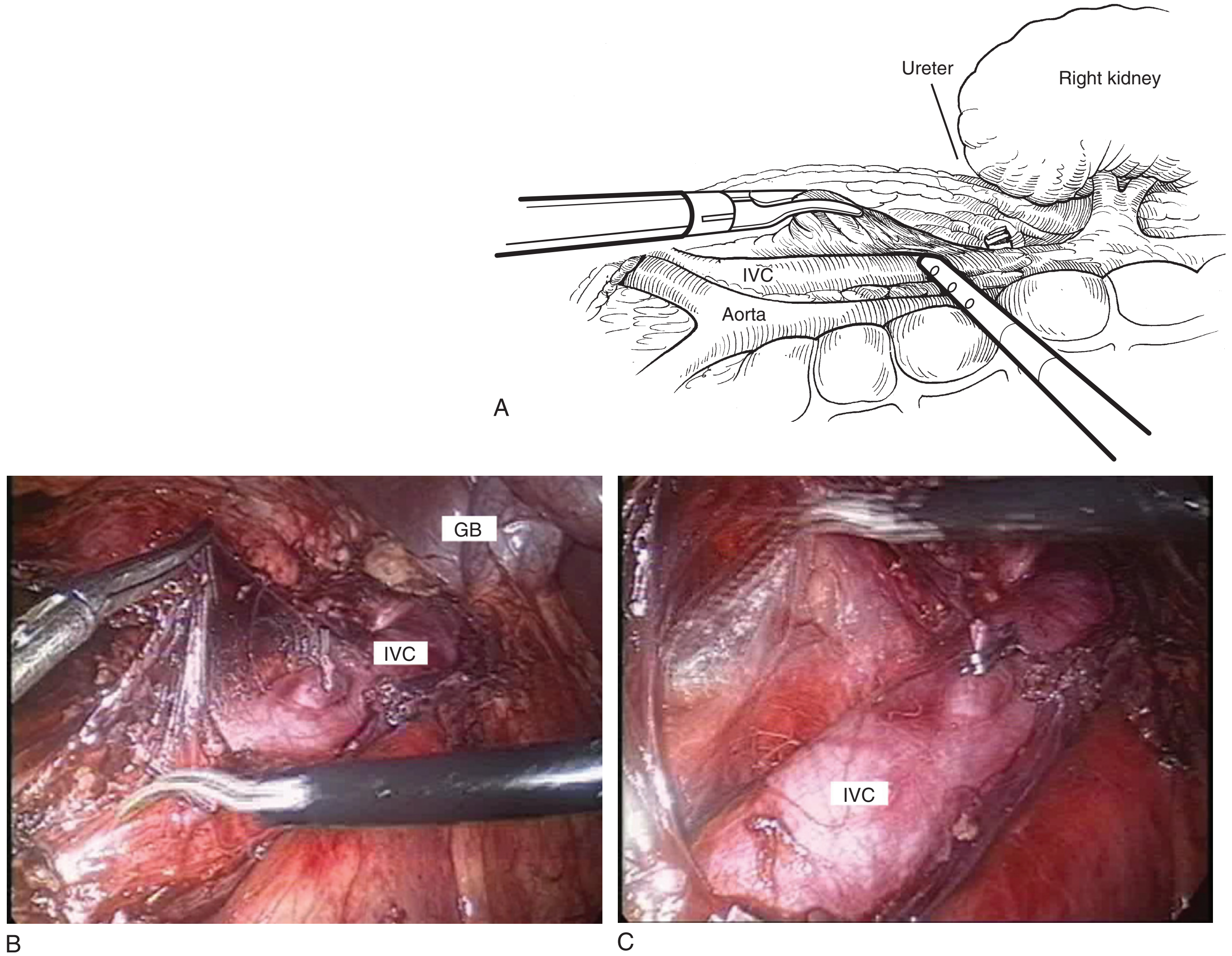


FIGURE 21–11. *A,* The adventitia overlying the vena cava is divided from the level of the renal vein to the bifurcation of the common iliac vessels. Electrocautery is used to longitudinally score the tissues and blunt dissection is used to further separate these tissues along the length of the inferior vena cava. *B,* The clips mark the site of transected gonadal vein. GB, gallbladder; IVC, inferior vena cava. *C,* The anterior surface of the vena cava is cleared of lymphatics and the gonadal vein clipped and divided on the surface of the vena cava. Using blunt and sharp dissection, the lymphatic tissue is then reflected laterally, toward the ureter.

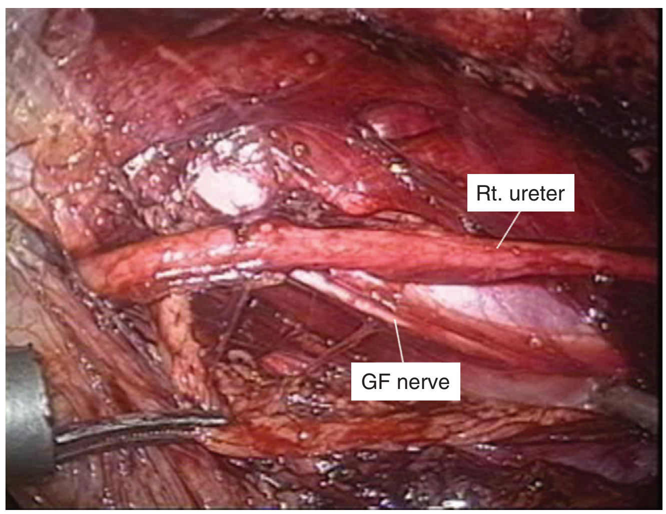


FIGURE 21–12. The dissection proceeds inferiorly, and the area bordered by the common iliac vessels and ureter is cleared of all lymphatic tissues. The genitofemoral (GF) nerve is seen in this view coursing anterior to the psoas muscle. Rt., right.

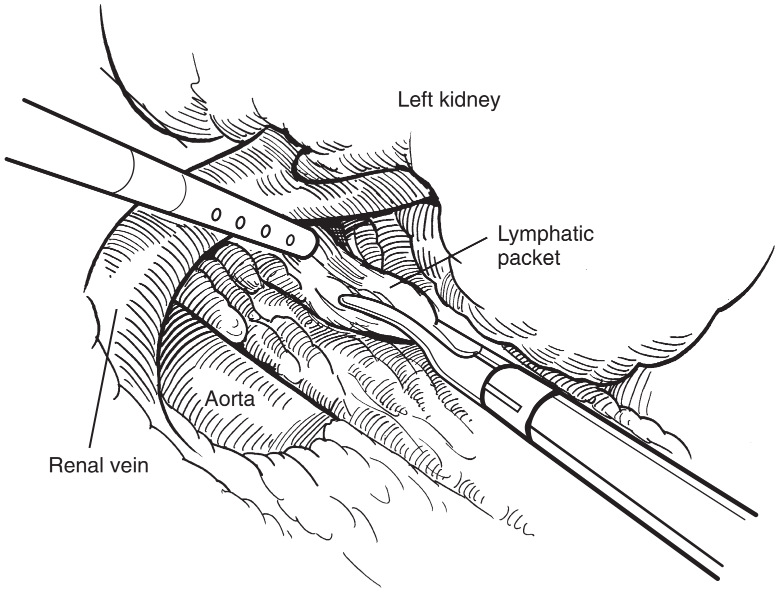


FIGURE 21–13. The renal artery and renal vein (including retroaortic veins) are always identified during the superior portion of this dissection and should not be confused for lumbar vessels.

artery) to avoid damage to the lumbar splanchnic nerves that may course into this region.

Lift the lateral nodal tissues and use the irrigation-suction device to gently separate these tissues from the underlying psoas fascia exposing small vessels and lymphatic channels. Ligate the lymphatic channels meticulously throughout the operation to minimize the risk of postoperative lymphocele formation. Carry the dissection superiorly to the renal vein, inferiorly to the common iliac vessels, and laterally to the ureter. Identify the sympathetic chains and leave them intact; do not mistake them for prominent lymphatic channels.

Interaortocaval Dissection

The paddle retractor is helpful in providing traction while medially rolling the remaining precaval/preaortic tissues to aid in their separation from the underlying great vessels. Identify the right renal artery and left renal vein (including retroaortic veins) during the superior portion of this dissection and do not confuse them for lumbar vessels (Fig. 21–13). Use blunt dissection with the irrigation-suction device to help define planes and separate nodal tissues from adjacent structures. Take particular care to avoid injury to the efferent sympathetic nerve fibers passing posterior to the IVC.

It is important to leave a long stump on the aorta/vena cava side when ligating lumbar vessels so that they can be grasped and controlled in the event a clip dislodges (Fig. 21–14). Lumbar vessels that retract into the iliopsoas muscle uncontrolled can usually be managed with pressure or a figure-of-eight stitch placed deep into the muscle. Lacerations of the IVC and aorta may occur during this operation and in the vast majority of cases do not mandate open conversion. Direct pressure usually prevents excessive hemorrhage and, in the case of venous bleeding, can achieve hemostasis without the need for additional maneuvers. Adjunct hemostatic agents also can be used successfully in this circumstance. If the bleeding persists or in the case of an aortotomy, direct pressure can be used temporarily before definitive repair is undertaken with intracorporeal suturing. In my experience, most venous lacerations can be managed without the need for intracorporeal suture repair. It is important, however, not to manipulate the tissue after hemostasis is achieved via direct pressure. Return to this part of the dissection after a period of time, allowing the tear to adequately seal.

Retrocaval and Retroaortic Dissection

The posterior body wall lymphatic tissues remain at this point. Use closed atraumatic forceps or an irrigation-suction device to develop a plane between the posterior nodal tissues and great vessels (see Fig. 21–14). After ligation of posterior lumbar vessels, use the irrigation-suction device to retract the vena cava/aorta anteriorly. Finally, use an atraumatic grasper to lift the vena cava/aorta, and gently tease the nodal packet off the undersurface of the great vessel. Then laterally transpose the packet to conclude the dissection. Place the specimen in an EndoCatch bag and extract it. A drain is not routinely placed. At the conclusion of the procedure, the surgical template should be clear of all lymphatic tissues (Fig. 21–15). Inspect the abdomen carefully and remove all trocars under direct vision. Use a Carter-Thomason device to close all port sites to prevent hernia formation.

POSTOPERATIVE MANAGEMENT

The orogastric tube is removed in the operating room, and the urinary catheter is usually removed on the first postoperative day. Patients are routinely transferred to the floor following the procedure. Blood work including hemoglobin, white blood cell count, electrolytes, and creatinine is obtained on postoperative days 1 and 2. A liquid diet is started on the morning following surgery and advanced to a regular diet as tolerated. Patients ambulate on postoperative day 1 and are typically discharged on postoperative day 2. By 2 weeks following surgery, there should be no restrictions on activity level. Patients requiring chemotherapy can typically start adjuvant therapy soon after their operation.

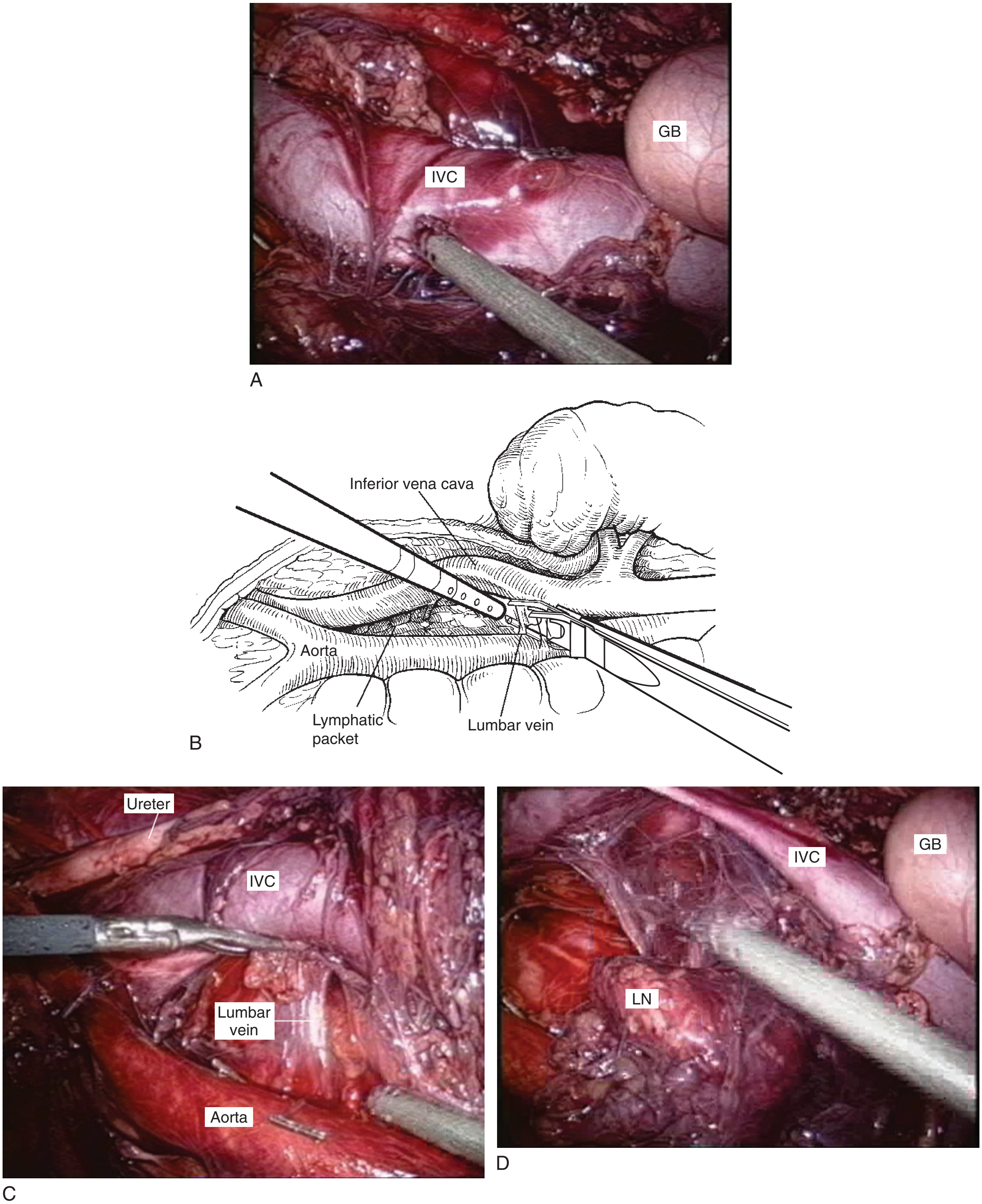


FIGURE 21–14. *A,* The precaval tissues are rolled medially to aid in their separation from the inferior vena cava (IVC). GB, gallbladder. *B,* Atraumatic forceps are used to develop a plane between the posterior nodal tissues and great vessels. Lumbar vessels interfering with the extraction of nodal tissues should be ligated and divided. It is important to leave a long stump on the aorta/vena cava side when clipping lumbar vessels so that they may be grasped and controlled in the event a clip dislodges. *C,* A grasper can be used to gently lift the vena cava/aorta so that the nodal packet can be teased off the undersurface of the great vessels. *D,* All retrocaval/retroaortic lymph nodes (LNs) are removed.

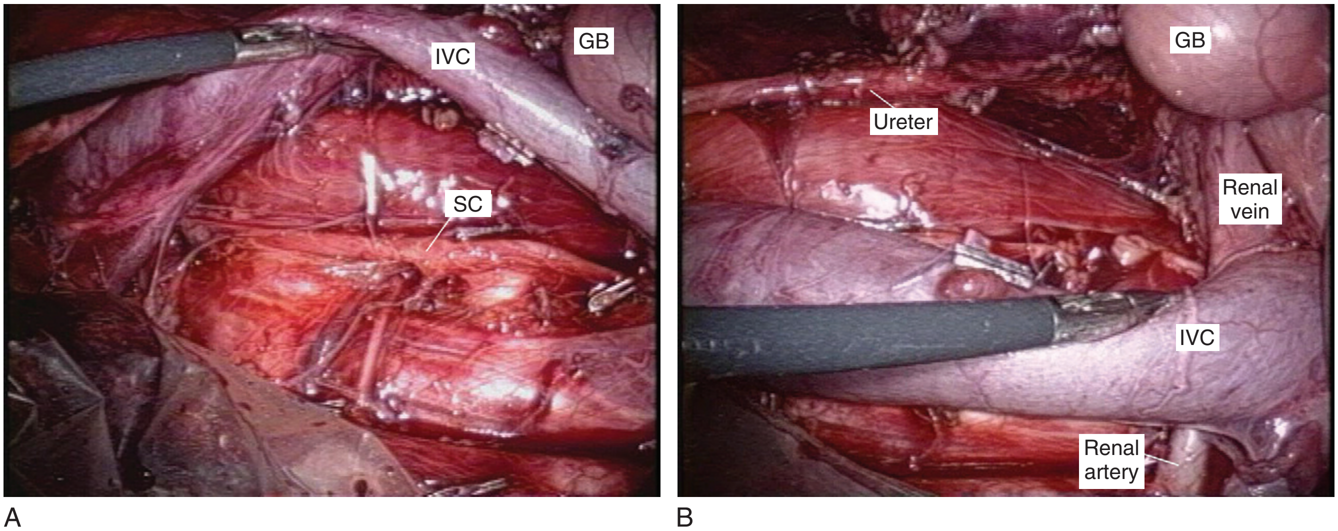


FIGURE 21–15. *A,* At the conclusion of the dissection, the template should be clear of all lymphatic tissues. All retrocaval nodes have been removed, and the sympathetic chain (SC) is clearly visualized. GB, gallbladder; IVC, inferior vena cava. *B,* The lateral zone and interaortocaval compartment are cleared of all lymphatic tissues. The superior border of the dissection is clearly visualized.

COMPLICATIONS

The spectrum of potential complications following laparoscopic RPLND is wide, but the rate of complications is low. A high level of suspicion must be maintained postoperatively in order to identify and limit the sequelae of developing complications. Unrecognized bowel injury and delayed bleeding, although rare, are potentially fatal complications, and a high degree of vigilance is the key to prompt diagnosis. Unrecognized bowel injuries may present in an atypical fashion with pain at one trocar site (out of proportion to other sites), low-grade fever, leukopenia, abdominal distention, and diarrhea even in the absence of frank peritoneal signs and ileus.[6] Prompt imaging with CT scan is helpful in establishing the diagnosis, and immediate reexploration is mandated to repair these injuries.[7] Intraoperative suspicion of pancreatic injury should result in prompt repair and placement of a drain. Intraoperative injury to the gallbladder usually results in a cholecystectomy without sequelae. Chylous ascites may develop following RPLND and can be prevented with meticulous ligation of lymphatic channels. Patients with chylous ascites may present with abdominal distention, ileus, and leakage of fluid from a port site. Diuretics and a low-fat diet with medium-chain triglycerides or total parenteral nutrition is the first line of therapy. No intervention is indicated in the management of asymptomatic lymphoceles, while symptomatic ones may be percutaneously drained. Retrograde ejaculation is rarely encountered following laparoscopic RPLND.[8,9]

SPECIAL INSTRUMENTS

Few special instruments are required for laparoscopic RPLND. Standard laparoscopic instruments are used throughout this procedure (e.g., atraumatic graspers, scissors, clip appliers, irrigation-suction device, and a laparoscopic paddle retractor). Radiolucent polypropylene clips (Hem-o-lock, Weck Closure Systems, Triangle Park, NC) may minimize artifact on postoperative imaging of the retroperitoneum. In addition, a needle driver loaded with 4-0 Prolene suture and adjunct hemostatic agents such as gelatin matrix (FloSeal Matrix Hemostatic Sealant, Fusion Medical Technologies, Fremont, CA) or oxidized cellulose (Surgicel, Ethicon Inc., Piscataway, NJ) should be available and ready in case of vascular injury. Ultrasonic shears should not be used because they may be unreliable in sealing large lymphatic channels.

Tips and Tricks

- Limit use of energy sources (ultrasonic shears, cautery) and maximize clip usage during dissection to avoid lymphatic complications.
- Use of radiolucent polypropylene clips may minimize artifact on postoperative imaging of the retroperitoneum.
- Leave a long stump on the aorta/vena cava side when ligating lumbar vessels such that they can be grasped and controlled in the event a clip dislodges.
- Lumbar vessels that retract into the iliopsoas uncontrolled can usually be managed with pressure or a figure-of-eight stitch placed deep into the muscle.
- Direct pressure and adjunct hemostatic agents may be used successfully to manage venous bleeding, including cavotomy, without the need for suturing.
- If bleeding persists or in the case of an aortotomy, direct pressure can be used temporarily before definitive repair is undertaken with intracorporeal suturing.
- Inserting a lap pad into the patient early makes it available in case of unexpected bleeding.
- Beware of retroaortic renal veins and accessory renal vessels; these can be confused with lumbar vessels.
- Ureteral stents may be placed to help with ureteral identification particularly in the postchemotherapy setting.
- Placing a clip proximally on the spermatic cord will prevent bleeding in the event the spermatic vein is injured while trying to free up the orchiectomy suture distally.

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CHAPTER 22

Nerve-Sparing Laparoscopic Radical Prostatectomy: Transperitoneal Technique

Li-Ming Su

Schuessler and colleagues[1] were the first to perform and report on a transperitoneal approach to laparoscopic radical prostatectomy (LRP) in 1992. In their 1997 report on a series of nine patients, they found that operative times for LRP were long (range, 8–11 hours), as was the average length of hospital stay of 7.3 days (range, 1–22 days), concluding that despite equivalent oncologic outcomes LRP offered no significant advantages over open surgery. As a result, LRP was not widely adopted into urologic practice.

In 2000 the field of urology witnessed a renewed interest in LRP, as a result of promising reports from two urologic centers of excellence in France that reported on their stepwise techniques and early outcomes with transperitoneal LRP.[2,3] Their approach proved to be both reproducible and teachable with operative times reported in the 4- to 5-hour range. Both groups reported excellent continence rates (Guillonneau and Vallancien,[2] 72%; Abbou and colleagues,[3] 84%) and potency was maintained in 45% of men who were potent preoperatively in the series by Guillonneau and Vallancien.[4] As a consequence of their pioneering work, these two centers rekindled worldwide interest in LRP. Since then, transperitoneal LRP has become the standard of care in several centers in Europe and has been offered as a minimally invasive treatment option for clinically localized prostate cancer by several centers in the United States and abroad. This chapter will describe and illustrate in detail the technique of transperitoneal LRP with special attention to anatomic cavernous nerve preservation.

INDICATIONS AND CONTRAINDICATIONS

The indications for transperitoneal LRP are identical to those for open surgery: clinical stage T2 or less disease with no evidence of metastasis either clinically or radiographically (abdominal/pelvic computed tomography and bone scan). Contraindications include uncorrectable bleeding diatheses or severe cardiopulmonary compromise that precludes the possibility for general anesthesia. Patients with a history of prior complex lower abdominal/pelvic surgery, morbid obesity, large prostate size (e.g., >100 g), prior pelvic irradiation, neoadjuvant hormonal therapy, or prior prostate surgery (e.g., transurethral resection of the prostate) are more challenging, but these features are not by themselves contraindications for LRP.[5–8] Nevertheless, these challenging cases should be avoided during a surgeon's early experience with LRP.

PATIENT PREOPERATIVE EVALUATION AND PREPARATION

Bowel Preparation

On the day before surgery, patients are advised to ingest one bottle of citrate of magnesium and limit their diet to clear liquids. A Fleet enema is self-administered the day of surgery. A single dose of a broad-spectrum antibiotic (e.g., first-generation cephalosporin or suitable alternative for patients allergic to penicillin) is administered intravenously 30 minutes before surgery.

Informed Consent

In addition to bleeding, transfusion, and infection, patients undergoing LRP must be aware of the potential for conversion to open surgery. As with open surgery, patients must be counseled on the risk of impotence, incontinence, incisional hernia, and adjacent organ injury (e.g., ureter, rectum, bladder, small bowel). The risks of general anesthesia must also be presented to the patient.

OPERATING ROOM CONFIGURATION AND PATIENT POSITIONING

LRP is one of the most challenging laparoscopic urologic procedures and requires a dedicated and experienced laparoscopic surgical team that includes a scrub technician, circulating nurse, surgical assistant, and anesthesiologist. These individuals must be well trained in the nuances of reconstructive laparoscopic surgery and versed in their individual roles in this operation. As frequent instrumentation changes are required, the scrub technician and circulating nurse must be knowledgeable about the various instruments used during transperitoneal LRP (Table 22–1). In general, only one skilled assistant is required to perform LRP; however, a second assistant may be

TABLE 22–1. EQUIPMENT AND INSTRUMENTATION FOR TRANSPERITONEAL LAPAROSCOPIC RADICAL PROSTATECTOMY

Automated Endoscopic System for Optimal Positioning (AESOP) 3000 robotic arm (Intuitive Surgical, Inc., Sunnyvale, CA)	5-mm trocars (three)
Monopolar electrocautery scissors	12-mm trocars (two)
Monopolar electrocautery hook device	Visiport device (U.S. Surgical, Norwalk, CT)
Bipolar forceps	20-French van Buren urethral sound
Ultrasonic shears	18-French silicone urethral catheter
Maryland dissector	10-mm specimen entrapment sack
60- and 90-degree fine-tipped (0.8 mm) dissectors	Small, medium-large, and extra-large Hem-o-lok clips (Weck Closure Systems, Research Triangle Park, NC)
Laparoscopic needle drivers (two)	2-0 Polyglactin suture (GS21) for dorsal venous complex
Suction-irrigation device	2-0 Polyglactin suture (UR6) for vesicourethral anastomosis
10-mm 0-degree laparoscope lens	
Veress needle	

useful if available to provide retraction and exposure. Operating room setup for transperitoneal LRP is as depicted in Figure 22–1.

After induction of general endotracheal anesthesia, place the patient in a supine position in steep Trendelenburg with arms tucked and padded at the sides (Fig. 22–2). Place sequential compression stocking devices on both legs and activate them. Spread the patient's legs far apart to allow for access to the rectum and perineum. Alternatively, place the patient's legs in stirrups in the low lithotomy position. Then secure the patient to the table at the level of the shoulders using heavy cloth tape. If available, attach an Automated Endoscopic System for Optimal Positioning (AESOP) 3000 robotic arm (Intuitive Surgical, Inc., Sunnyvale, CA) to the operative table at the level of the patient's right shoulder. Attach it to the laparoscope and control it either by voice activation or, alternatively, by the assistant using a hand-held remote control. Place an orogastric tube and urethral catheter to decompress the stomach and bladder, respectively.

Transperitoneal LRP requires a general anesthesia. Because the patient's arms are tucked at the sides during the operation, it is critical to establish accurate pulse oximetry, blood pressure cuff placement, and intravenous access before positioning the patient. The anesthesiologist must be aware of the potential consequences of CO_2 insufflation and pneumoperitoneum, including hypercarbia and oliguria. The anesthesiologist may need to make prompt adjustments in minute and tidal volumes in the event of rising end-tidal CO_2 levels and hypercarbia.[9] Adjustments in CO_2 insufflation pressures may also be required if a rise in end-tidal CO_2 level is detected.

TROCAR PLACEMENT

For a transperitoneal LRP approach, establish pneumoperitoneum using either a Veress needle inserted at the base of the umbilicus or an open trocar placement with a Hasson technique. In general, CO_2 insufflation pressure is maintained at 15 mm Hg throughout the operation. Secondary trocars are placed using laparoscopic guidance including a 12-mm right pararectus trocar, a 5-mm left pararectus trocar, and two 5-mm trocars placed half-way between the anterior-superior iliac crest and pararectus trocar on the right and left sides (Fig. 22–3; see Fig. 22–1*B*). The surgeon operates primarily through the two pararectus trocars, and the assistant, through the 5-mm trocar in the right lower quadrant. Use the left lower quadrant 5-mm trocar for retraction purposes and a second assistant, if available, or an endoscopic instrument holder can manipulate it.

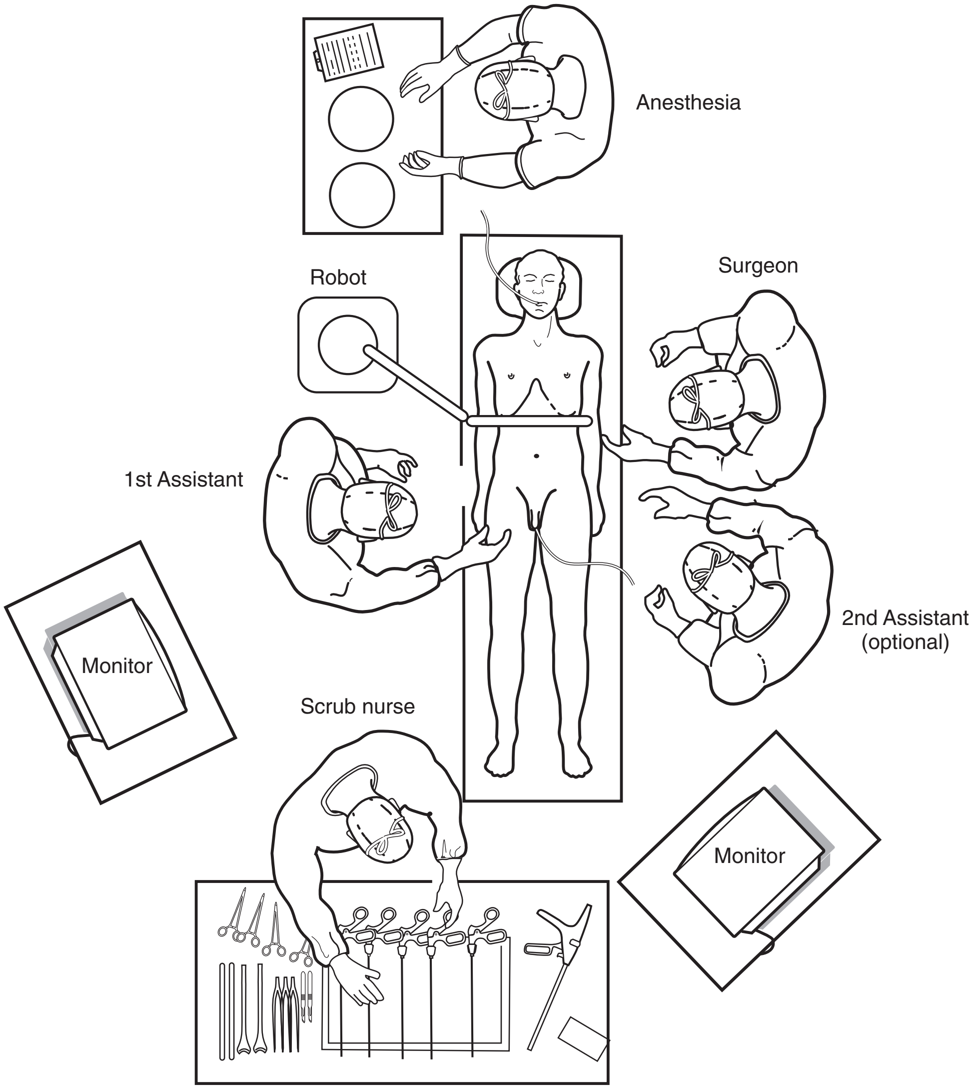
PROCEDUE

Dissection of the Seminal Vesicles and Vas Deferentia

Upon entry into the peritoneal cavity, the relevant visible landmarks include the bladder, median (urachus) and medial umbilical ligaments, vas deferentia, iliac vessels, and rectum (Fig. 22–4). During transperitoneal LRP, two different approaches (i.e., posterior and anterior) to dissection of the seminal vesicles have been described. With the Montsouris or posterior approach, the initial step is retrovesical dissection of the vas deferentia and seminal vesicles.[2] Sharply incise the peritoneum overlying the vas deferens. Divide the vas deferens and trace it distally toward the ipsilateral seminal vesicle, which is subsequently dissected (Fig. 22–5). The anterior approach involves initial retropubic exposure and dissection of the prostate followed by identification and dissection of the seminal vesicles after division of the bladder neck.[10] With both techniques, avoid using thermal energy, if possible, during dissection of the seminal vesicle in order to avoid injury to the nearby cavernous nerves.

Posterior Prostatic Dissection

After the assistant anteriorly lifts the seminal vesicles and vasa, make a 2- to 3-cm horizontal incision through Denonvillier's fascia approximately 0.5 cm below the base of the seminal vesicles (Fig. 22–6). Carry the dissection between Denonvillier's fascia and the rectum, hugging the posterior aspect of the prostate and sweeping off the attachments of the rectum in a posterior direction using blunt dissection. The presence of prerectal fat confirms the proper plane of dissection. Thorough dissection of the rectum off the posterior prostate is critical in order to minimize the risk of rectal injury during subsequent steps, such as dissection of the posterior prostatic apex. The lateral extent of this posterior dissection also serves as an important landmark (i.e., the medial border of the neurovascular bundle [NVB]) for future antegrade cavernous nerve dissection.



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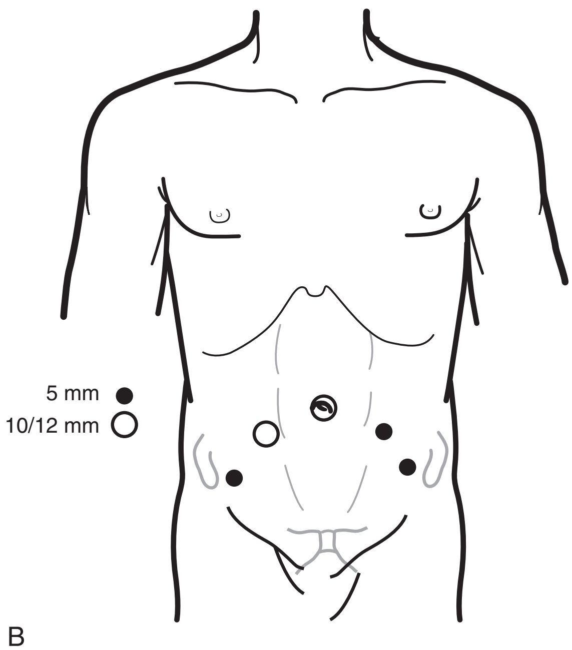

B

FIGURE 22–1. Operating room and trocar configuration for laparoscopic radical prostatectomy. *A,* The operating room is configured so that the entire team can see the procedure. The surgeon stands on the patient's left side. *B,* Our standard five-trocar configuration.

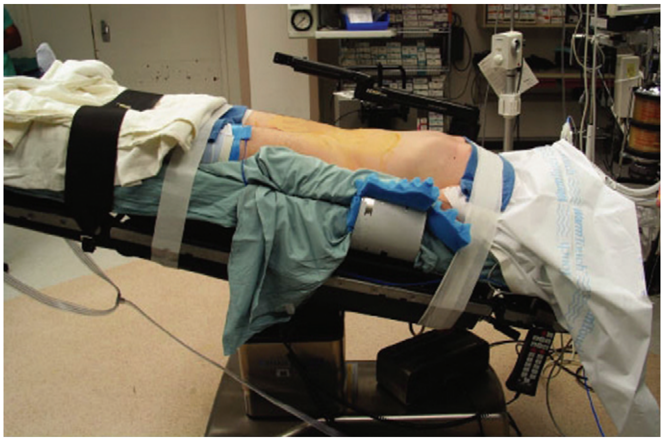

FIGURE 22–2. Patient positioning for transperitoneal laparoscopic radical prostatectomy. The patient's arms are tucked and padded at the sides with the operating table placed in the Trendelenburg position.

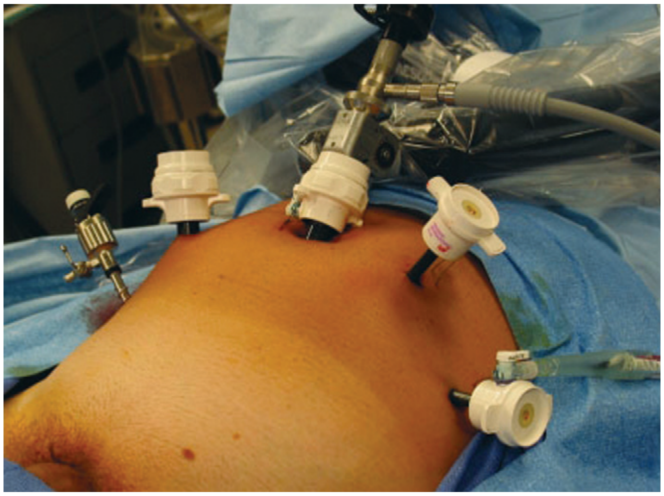

FIGURE 22–3. Trocor configuration for transperitoneal laparoscopic radical prostatectomy.

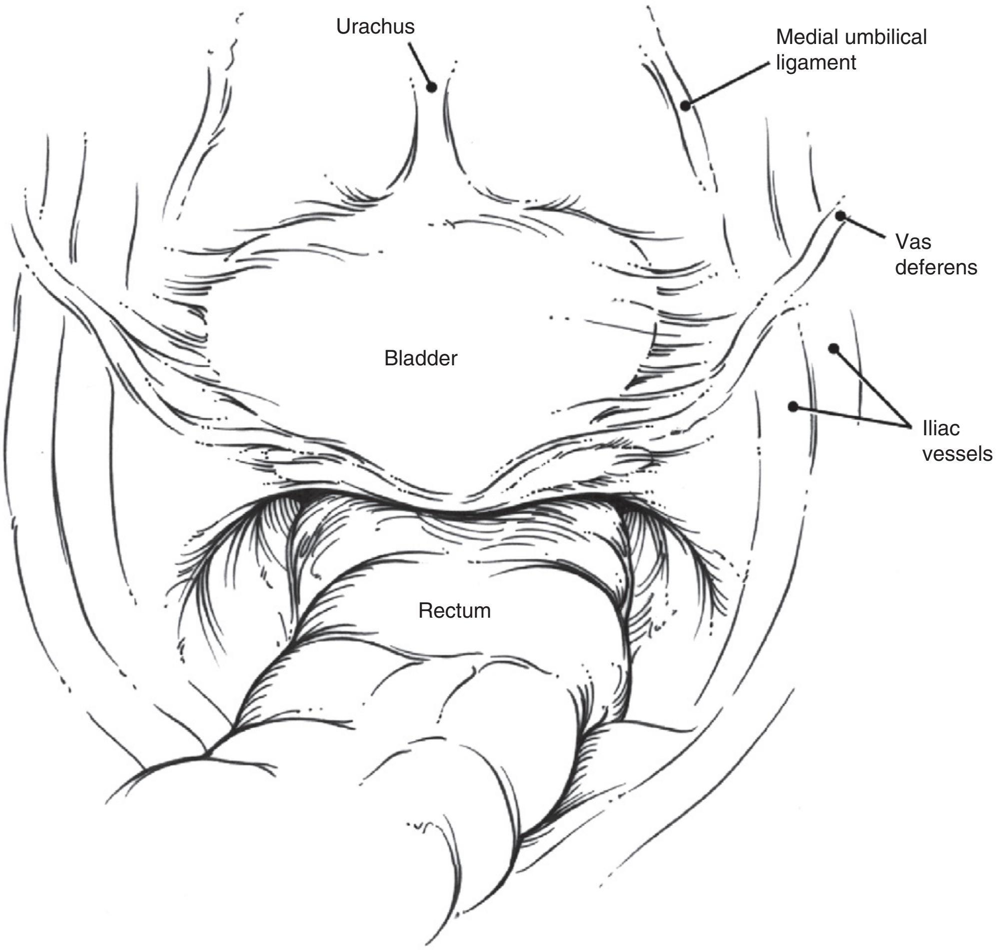

FIGURE 22–4. Initial intraperitoneal view detailing the relevant landmarks within the male pelvis during transperitoneal laparoscopic radical prostatectomy. (Drawn by Tim Phelps. Copyright © Johns Hopkins University.)

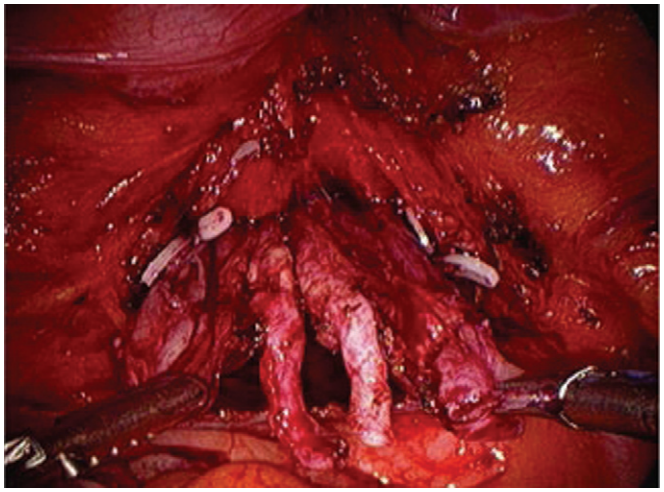

FIGURE 22–5. Seminal vesicle dissection. In lieu of using electrocautery for hemostasis, hemoclips are applied along the lateral aspect and tip of the seminal vesicle to secure the vascular pedicle and avoid thermal injury to the nearby neurovascular bundles. Completed bilateral seminal vesicle and vas dissection is shown.

Developing the Space of Retzius

Dissect the bladder from the anterior abdominal wall by dividing the urachus high above the bladder and incising the peritoneum bilaterally just medial to the medial umbilical ligaments using a hook electrocautery device. Applying cephalad and posterior traction on the urachus, identify and dissect the prevesical fat, exposing the space of Retzius (Fig. 22–7). Remove the fat overlying the anterior prostate, and coagulate the superficial branches of the dorsal venous complex (DVC) using bipolar electrocautery. Visible landmarks at this stage include the anterior aspect of the bladder and prostate, puboprostatic ligaments, endopelvic fascia, and pubic symphysis (Fig. 22–8). Sharply divide the endopelvic fascia and puboprostatic ligaments, exposing levator muscle fibers attached to the lateral and apical portions of the prostate. Meticulously and bluntly dissect these fibers from the surface of the prostate, exposing the prostatourethral junction.

Ligation of the Deep Dorsal Venous Complex

Ligate the deep DVC using a figure-of-eight 2-0 polyglactin GS21 suture, passing the needle beneath the DVC and anterior to the urethra (Fig. 22–9). Placing a 20-French metal van

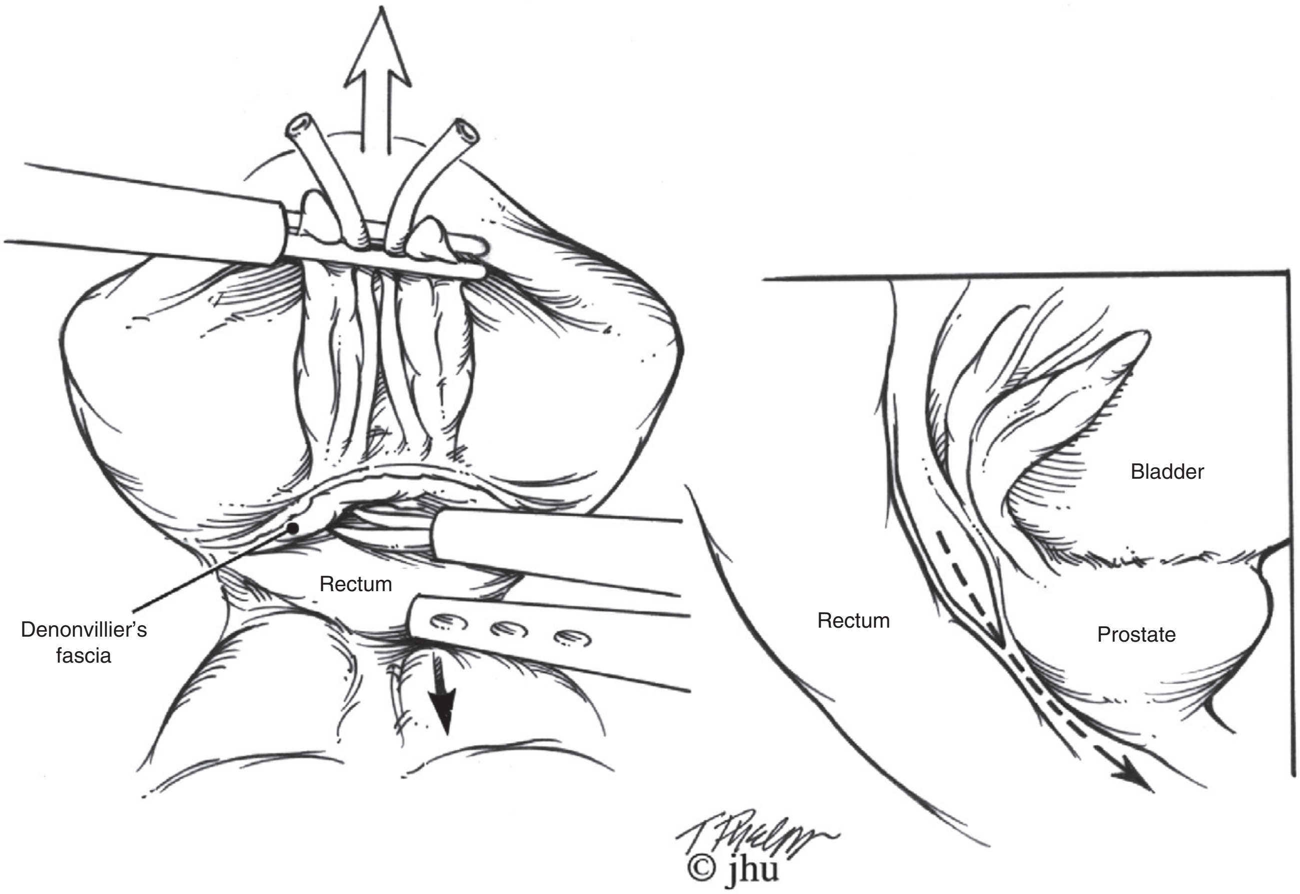

FIGURE 22–6. Posterior dissection of the prostate. As the assistant applies upward traction on the seminal vesicles and vasa and downward traction on the rectum, a transverse incision is made in Denonvillier's fascia below the seminal vesicles and blunt dissection is used to develop a plane between Denonvillier's fascia and the rectum. *Inset* demonstrates the direction of posterior dissection toward the prostatic apex. (Drawn by Tim Phelps. Copyright © Johns Hopkins University.)

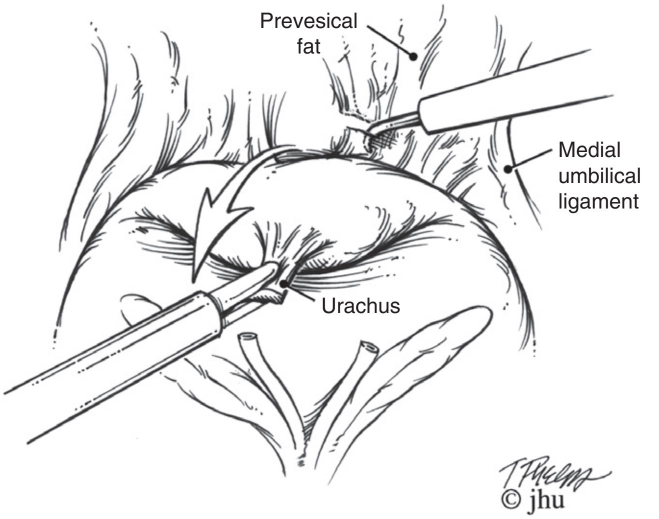

FIGURE 22–7. Division of urachus and entry into the space of Retzius. Cephalad and posterior traction on the urachus helps to identify the fatty alveolar tissue immediately anterior to the bladder, marking the proper plane of dissection. The medial umbilical ligaments demarcate lateral extent of the bladder dissection. (Drawn by Tim Phelps. Copyright © Johns Hopkins University.)

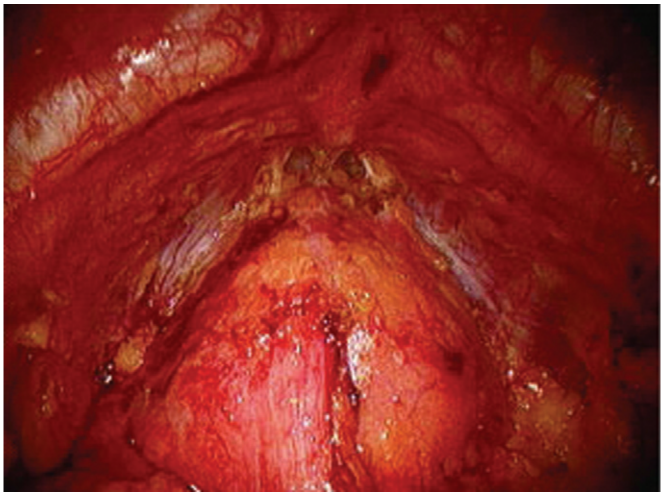

FIGURE 22–8. Retropubic view of the bladder and prostate following entry into the space of Retzius. The fatty tissue overlying the anterior aspect of the prostate has been removed, exposing the puboprostatic ligaments and endopelvic fascia.

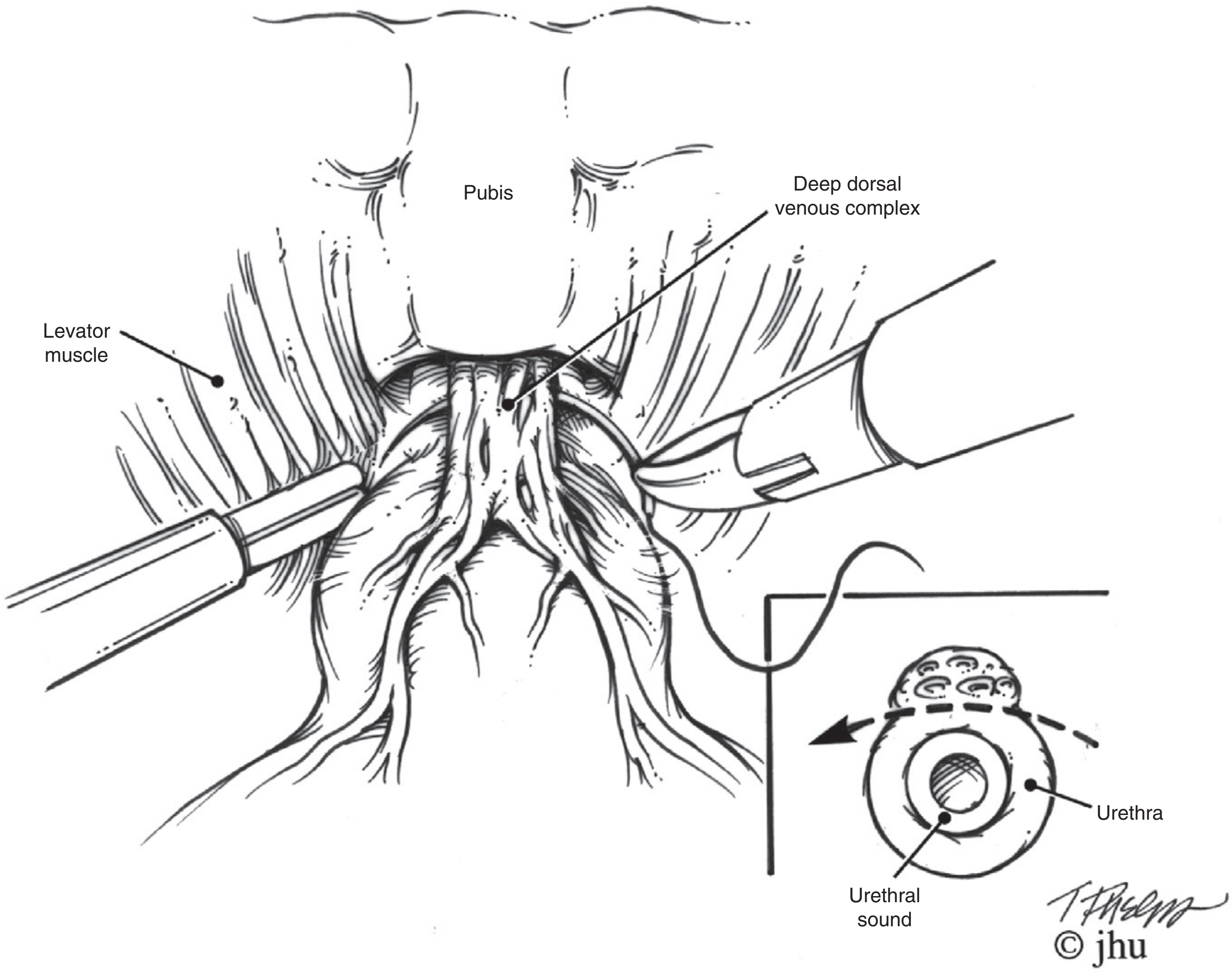

FIGURE 22–9. Ligation of the deep dorsal venous complex. A suture is passed from right to left, ligating the dorsal vein as distal as possible. *Inset* demonstrates the proper passage of the needle immediately anterior to the urethra. A urethral sound can be placed to ensure that the urethra is not incorporated in the suture. (Drawn by Tim Phelps. Copyright © Johns Hopkins University.)

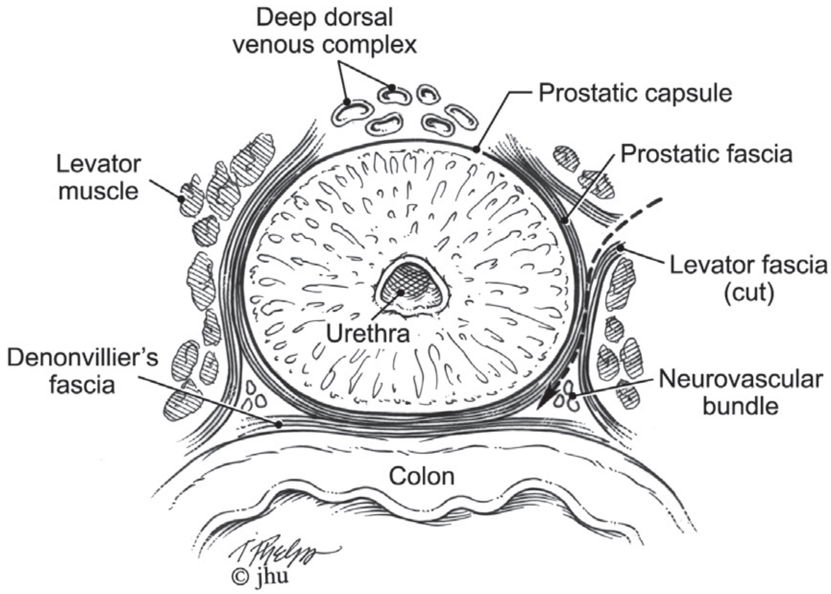

FIGURE 22–10. Cross section of the prostate demonstrating the periprostatic fascial planes with respect to the location of the neurovascular bundles. Following anteromedial incision of the levator fascia, the dashed line indicates the direction of interfascial dissection (i.e., between the levator and prostatic fascia) to accomplish release of the neurovascular bundle from the prostate. (Drawn by Tim Phelps. Copyright © Johns Hopkins University.)

Buren urethral sound while applying posterior traction can help ensure that the DVC suture is placed as distal as possible and that the urethra is not incorporated in the suture. The DVC remains ligated during the operation until immediately before transection of the prostatic apex from the urethra. Securing the DVC as far away from the prostatic apex as possible can help minimize the chance of the suture being cut and avoid iatrogenic entry into the prostatic apex during division of the DVC. A second suture may be placed along the anterior bladder neck to prevent venous back bleeding. An alternative method for management of the DVC is ligation and division of the venous complex near the end of the operation only after the prostate and NVB have been entirely freed save the prostatourethral attachment. This technique ensures that the precise course of the NVBs is clearly visualized adjacent to the DVC and therefore avoided during ligation of the venous complex.

Lateral Interfascial Dissection of the Neurovascular Bundles

The NVB travels between two distinct fascial planes that surround the prostate, namely the prostatic fascia and levator fascia (Fig. 22–10). Make an opening in the levator fascia by sharply incising this fascia along the anteromedial surface of the prostate starting at the base of the prostate and proceeding toward the apex. Gently develop the interfascial plane (i.e., between the levator and prostatic fascia), dissecting as close to the prostatic fascia as possible in an effort to optimize quantitative cavernous nerve preservation. I have found that modified (0.8 mm tipped) right-angled and curved dissectors are useful for defining and developing this potential plane between the levator and prostatic fascia[11] (Fig. 22–11). When possible, create a groove between the NVB and prostate (i.e., the lateral NVB groove) by progressively developing this interfascial plane deeper toward the posterolateral aspect of the prostate. In some cases, periprostatic vessels traveling between the fascial planes may prevent successful development of the lateral NVB groove.

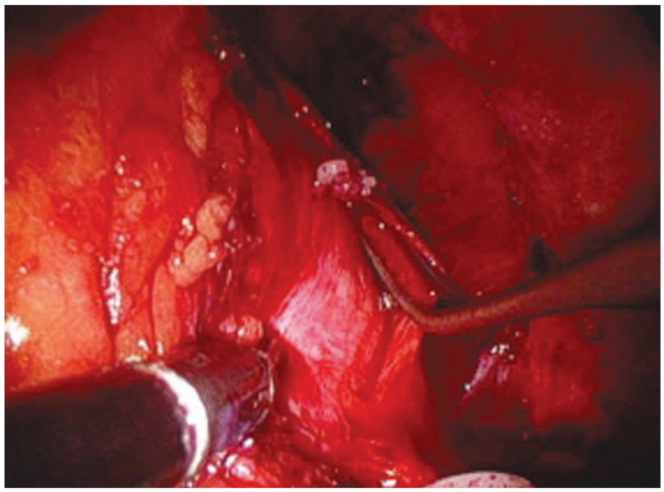

FIGURE 22–11. Developing the right lateral neurovascular bundle groove. After incising the right levator fascia, a fine-tipped curved dissector is used to develop the interfascial plane between the levator and prostatic fascia.

If bleeding occurs from these periprostatic vessels, temporarily increase CO_2 insufflation pressure and apply pressure to the source of bleeding with hemostatic gauze. Avoid hemostasis with electrocautery or ultrasonic heat energy, if possible, during dissection near the NVBs because these energy sources have been shown to be harmful to cavernous nerve function in the canine model.[12]

Bladder Neck Transection and Prostatic Pedicle Ligation

The proper plane of dissection between the bladder and prostate may be challenging to identify in a surgeon's early experi-

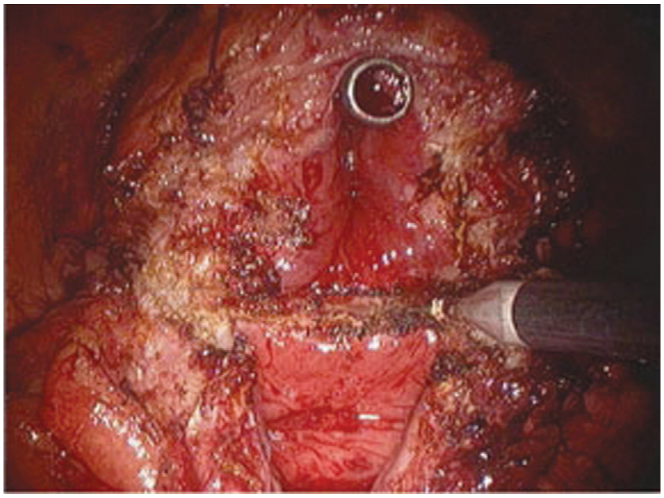

FIGURE 22–12. Posterior bladder neck transection using a hook monopolar electrocautery device. Cephalad traction on the bladder and anterior traction of the prostate with the urethral sound can help expose and delineate the posterior bladder neck margin.

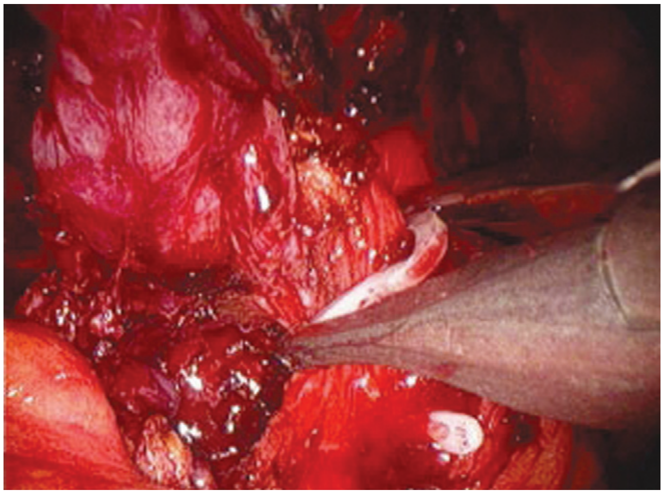

FIGURE 22–13. Intraoperative view demonstrating application of an extra-large Hem-o-lok clip (Weck Closure Systems, Research Triangle Park, NC) to secure the right prostatic pedicle. The pedicle is subsequently sharply divided close to the prostate surface without electrocautery.

ence with LRP. Identification of this plane of dissection can be facilitated by applying anterior traction with the tip of a van Buren urethral sound or by placing traction on an inflated Foley catheter balloon. However, with experience, this plane can be identified easily by inspecting the contour of the prostate and bladder neck and looking at the subtle transition between the prevesical fat and prostate. Divide the anterior bladder using ultrasonic shears or monopolar hook electrocautery. Inspect the bladder trigone to identify the presence or absence of a protruding median prostatic lobe and to locate the ureteral orifices before dividing the posterior bladder neck with a hook electrocautery device (Fig. 22–12). In the event of a median lobe, it can be helpful to apply anterior traction on the prostate using either a urethral sound or urethral catheter to lift the prostate and expose the posterior bladder neck below the protruding median lobe. If the seminal vesicles and vas deferentia have been previously dissected, identify them along the midline, grasp them, and bring them through the opening created between the bladder neck and prostate. Otherwise, identify and dissect them free at this time. The assistant lifts the seminal vesicles and vasa anteriorly, defining the prostatic pedicles located at the 5- and 7-o'clock positions entering into the base of the prostate. Different methods have been described to control the prostatic pedicle. Some surgeons primarily use bipolar electrocautery, whereas others advocate temporary bulldog clamp occlusion and suturing of the pedicle.[13] I prefer to use medium-large or extra-large Hem-o-lok clips (Weck Closure Systems, Research Triangle Park, NC) to secure the pedicle, and I avoid using thermal energy (Fig. 22–13).

Antegrade Neurovascular Bundle Preservation

After division of the prostatic pedicles, carry dissection out toward the previously defined lateral NVB groove in an antegrade or descending direction (Fig. 22–14). The posterior dissection between the rectum and prostate has already been completed; therefore, the medial border of the NVB is already visibly defined. Both the medial border of the NVB and lateral NVB groove serve as critical landmarks to help guide the proper angle and direction of dissection to optimize antegrade NVB preservation. Once the pedicle is completely divided, gently tease the remaining attachments between the nerve bundles and posterolateral prostate off the posterolateral surface of the prostate using a combination of blunt and sharp dissection (Fig. 22–15). When small vessels coursing between the NVB and prostate are encountered, apply small hemoclips as needed. Carry antegrade dissection of the NVBs as far as possible toward the apex. Minimize the use of electrocautery and direct manipulation of the NVB to avoid injury to the cavernous nerves.

Retrograde Neurovascular Bundle Preservation

An alternative method of cavernous nerve preservation follows that of the retrograde or ascending technique, similar to that described in open radical retropubic prostatectomy by Walsh and colleagues.[14] With this technique, following ligation and immediate division of the DVC, divide the anterior and posterior urethra at the prostatourethral junction. Develop the plane between the levator and prostatic fascia and release the NVBs from the apex toward the base in a retrograde fashion. The DVC is divided early in the operation and the prostatic pedicles are divied late; therefore, there is potentially a greater risk of ongoing bleeding with the retrograde technique during NVB dissection.[15] In contrast, during the antegrade NVB dissection, the arterial blood supply to the prostate (i.e., the prostatic pedicles) is divided early and the DVC is divided near the end of the operation, thus reducing ongoing blood loss during the operation.

Division of the Deep Dorsal Venous Complex

Divide the DVC just proximal to the previously placed DVC suture. Take great care to avoid inadvertent entry into the

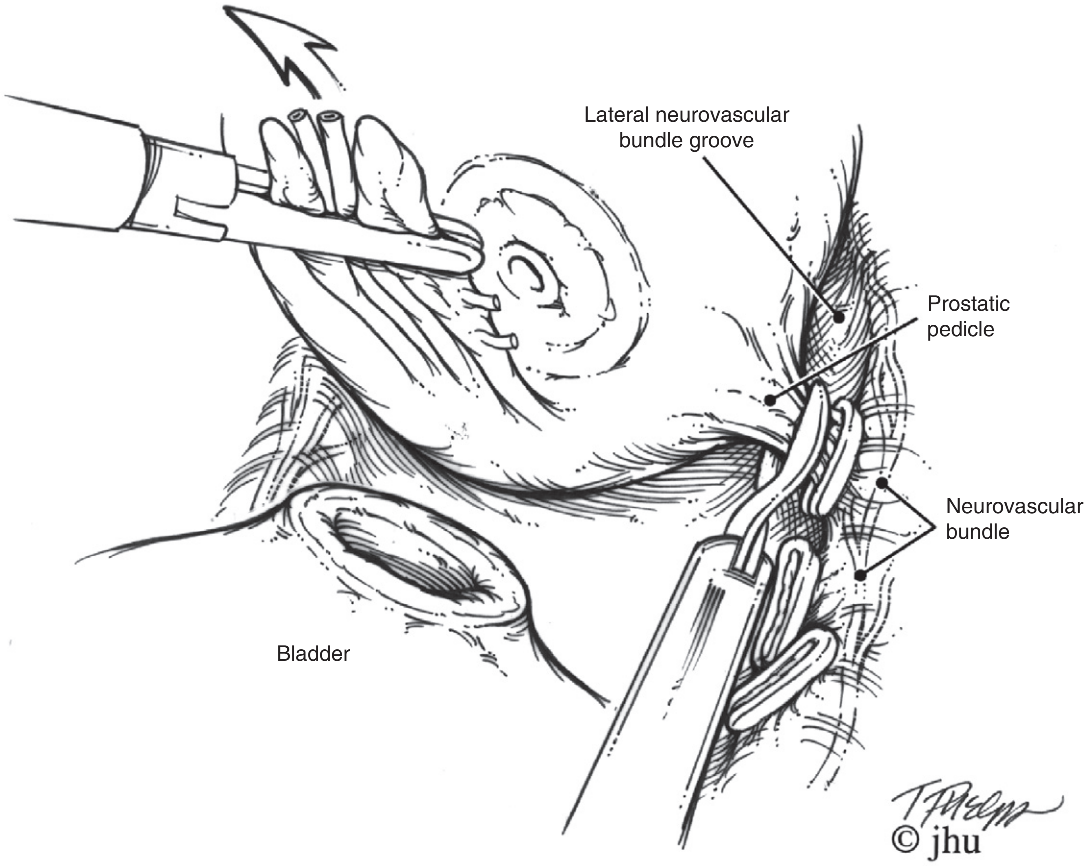

FIGURE 22–14. Ligation of the right prostatic pedicle and antegrade dissection of the neurovascular bundle. With anterior traction on the seminal vesicles and vasa, the prostatic pedicles are identified and clipped and divided without electrocautery, staying close to the prostate surface. Direction and course of antegrade neurovascular bundle dissection are guided by the previously defined lateral neurovascular bundle groove. (Drawn by Tim Phelps. Copyright © Johns Hopkins University.)

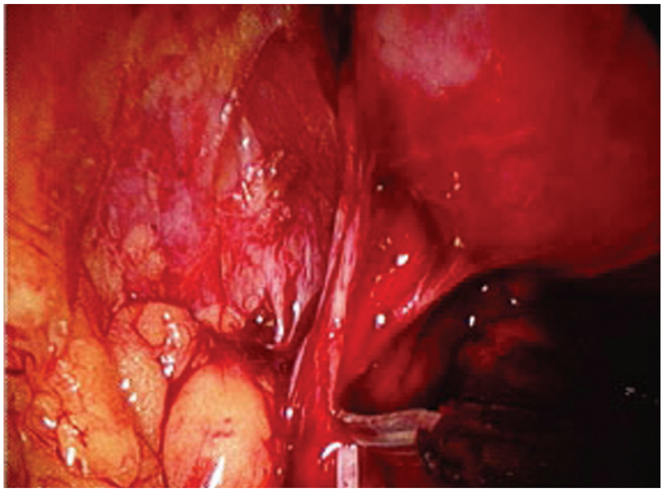

FIGURE 22–15. Antegrade dissection of the left neurovascular bundle. Intraoperative view demonstrating the fine V-shaped attachments between the left neurovascular bundle and the posterolateral surface of the prostate. Using both blunt and sharp dissection, the nerve bundle is gently swept off of the posterolateral surface of the prostate in the direction of the apex.

prostatic apex, resulting in an iatrogenic positive apical margin. Spot electrocautery may be required for minor bleeding from the DVC; avoid electrocautery immediately adjacent to the NVBs. Rarely, placement of additional DVC sutures is required if unexpected large venous sinuses are encountered. After complete division of the DVC, the anterior aspect of the prostatourethral junction should be visible.

Prostatic Apical Dissection and Division of Urethra

The distal portion of the NVBs lie in intimate association with the lateral aspect of the prostatic apex; therefore, gently and meticulously dissect free the remaining attachments between the NVB and prostatic apex using a fine right-angled dissector and sharp dissection without electrocautery. By withdrawing the van Buren urethral sound into the prostatic urethra, the tip of the urethral sound can be useful for defining the precise junction between the prostatic apex and urethra, thus optimizing preservation of urethral length. Sharply divide the anterior urethra, taking care to avoid and preserve the NVBs coursing along the posterolateral surface of the urethra (Fig. 22–16). Before division of posterior urethra, take great care to inspect the contour of the posterior prostatic apex. In some patients,

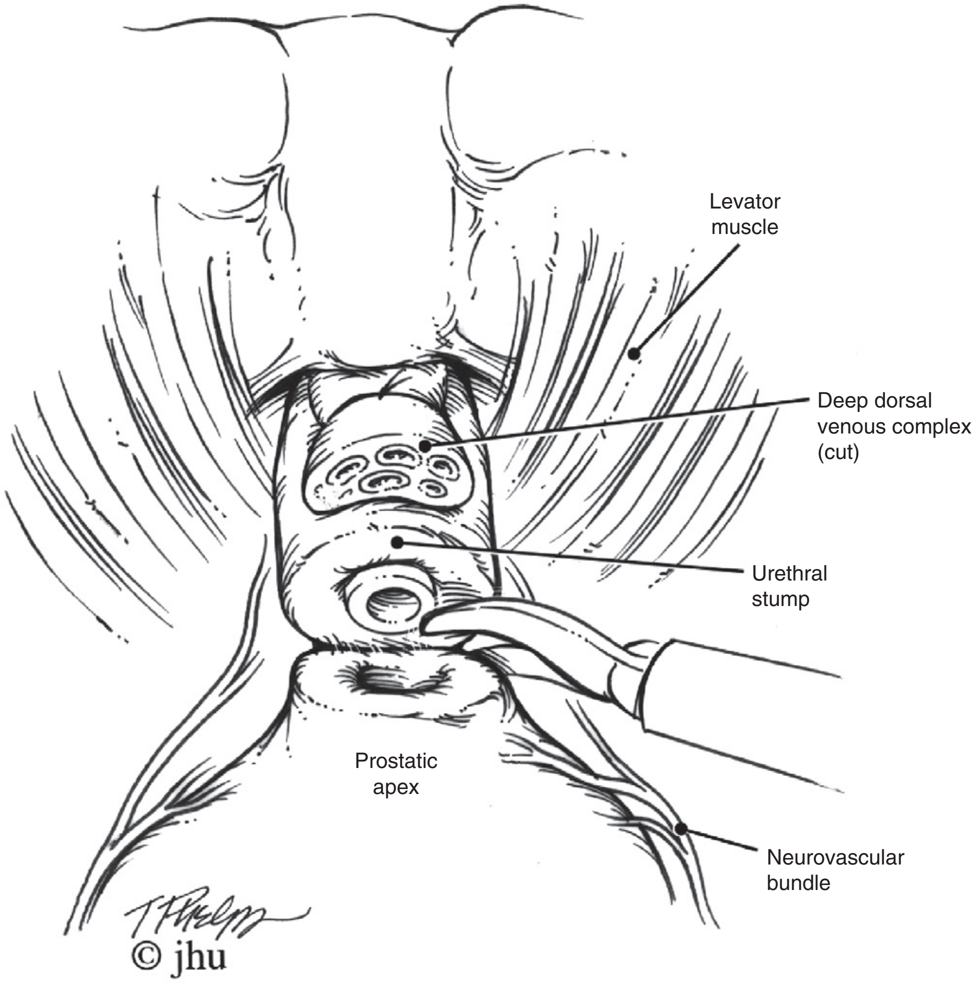

FIGURE 22–16. Division of urethra. Following division of the deep dorsal venous complex, the anterior and posterior urethra is sharply divided without electrocautery. Using the tip of a urethral sound, the precise point for transection of the urethra from the prostatic apex can be identified. (Drawn by Tim Phelps. Copyright © Johns Hopkins University.)

the anterior and posterior prostatic apex is asymmetric with protrusion of the posterior prostatic apex beneath the urethra. If not identified, transection of the posterior prostatic apex flush with the anterior margin may result in an iatrogenic posterior apical positive margin. Having already completed the posterior prostatic dissection, little additional dissection is typically required to free the prostate in its entirety once the posterior urethra and posterior striated urethral sphincter complex is divided.

Laparoscopic Inspection and Entrapment of the Prostate Specimen

Once the prostate is released completely, closely inspect the specimen margins laparoscopically. If there is concern about a positive margin, excise additional tissue and send it for frozen section at this time. If needed, temporarily place hemostatic gauze alongside the NVBs if small venous bleeding is identified and then remove the gauze before accomplishing the vesicourethral anastomosis. When indicated, perform laparoscopic bilateral pelvic lymph node dissection before accomplishing the anastomosis. Place the lymph node specimens and the prostate in an entrapment sac and store them in the right lower quadrant of the abdomen until completion of the operation.

Vesicourethral Anastomosis

The critical first step in successfully accomplishing the vesicourethral anastomosis is to establish a secure posterior anastomosis, the site with the relatively greatest tension. Sutures along the posterior anastomosis are at risk for disruption with subsequent urinary leakage during passage of the urethral catheter if proper mucosa-to-mucosa approximation of the posterior anastomosis is not established. To avoid this complication, the assistant applies pressure to the perineum using a sponge stick to better reveal the posterior urethra. The assistant may also grasp the posterior bladder neck with a Maryland dissector or "hook" the trigone with the tip of a suction irrigator device in order to approximate the posterior bladder neck to the urethra. These maneuvers can reduce tension at the posterior anastomosis while the surgeon places and secures the sutures. Last, to further reduce tension at the anastomosis, release the lateral bladder attachments from the pelvic side

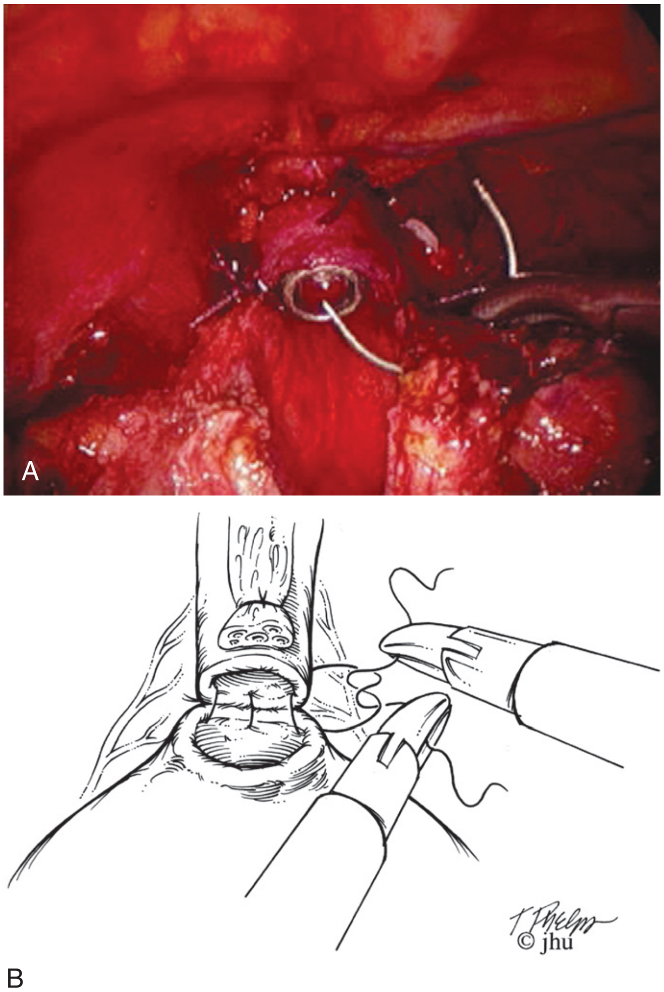

FIGURE 22–17. Interrupted vesicourethral anastomosis. *A*, Intraoperative view demonstrating a completed posterior anastomosis. *B*, Great care must be taken to avoid incorporating the neurovascular bundles when placing and tying the sutures. (Drawn by Tim Phelps. Copyright © Johns Hopkins University.)

wall and bring the operating table out of the Trendelenburg position.

The vesicourethral anastomosis may be accomplished using 2-0 polyglactin UR6 suture with either an interrupted (Fig. 22–17) or a running continuous single knot suture.[16] Take great care so as to not incorporate the NVBs into the anastomotic sutures. Either an anterior or a posterior "tennis racquet" closure of the bladder neck may be required if there is significant discrepancy between the bladder neck opening and urethra. Place a urethral catheter under direct vision before completing the anastomosis, and then test the anastomosis by filling the bladder with 100 to 150 mL of saline. Repair visible leaks at the anastomosis with additional sutures as necessary. Leave a closed-suction drain to drain the prevesical space.

Delivery of the Prostate Specimen and Exiting the Abdomen

Deliver the entrapment sac containing the prostate and lymph node specimens via extension of the infraumbilical incision and abdominal fascia. Close the fascia of the infraumbilical and 12-mm trocar site primarily to prevent incisional hernia. The 5-mm trocars generally do not require fascial closure.

POSTOPERATIVE MANAGEMENT

Patients are given parenteral analgesics for postoperative pain overnight and switched to oral pain medication on the first postoperative day. Clear liquids are initiated on the first postoperative day, and patients are gradually advanced to a regular diet as tolerated. The closed-suction drain is removed when the output is minimal, and the patient is discharged on either postoperative day 1 or 2 with the urethral catheter to straight drainage.

A gravity cystogram is performed on postoperative day 7, and the urethral catheter is removed if no extravasation is identified at the vesicourethral anastomosis. In the event of extravasation, the urethral catheter is kept in place and a cystogram is repeated in 1 to 2 weeks.

COMPLICATIONS

Overall Complication Rate and Severity of Complications

Guillonneau and colleagues[17] presented a comprehensive description of the incidence and types of perioperative complications following 567 consecutive LRPs over a 3-year period. They reported a total, major, and minor complication rate of 17%, 4%, and 14.6%, respectively. Other series have reported complication rates with LRP between 4% and 12%.[18] Gonzalgo and colleagues[19] applied a morbidity grading scheme designed to detail the frequency and severity of complications following LRP. A total of 34 (13.8%) morbidities were encountered during 246 LRP cases, the majority (94.1%) of which were self-limited (i.e., grade II or III). There were only two (5.9%) grade IV complications (i.e., potentially life-threatening requiring intensive care unit management) and no grade V complications (i.e., deaths). Postoperative ileus and bleeding requiring transfusion were the most frequent complications, with an incidence of 3.3% and 2.8%, respectively.

Specific complications during transperitoneal LRP are worthy of mention, as well as their management and methods for prevention.

Postoperative Ileus

As with any transabdominal surgery, transient postoperative ileus can occur following LRP but rarely persists beyond postoperative day 2. One unique cause of postoperative ileus following transperitoneal LRP is urinary ascites. During the transperitoneal approach, the vesicourethral anastomosis is in direct communication with the peritoneal cavity, resulting in the potential for urinary ascites with subsequent peritoneal irritation and ileus if extravasation of urine occurs from the anastomosis. This highlights the importance of achieving a water-tight, tension-free vesicourethral anastomosis. In the event of urinary ascites, proper positioning and functioning of the urethral catheter should be confirmed, with prolonged

bladder drainage to allow for spontaneous closure of the anastomotic leak.

Rectal Injury

Rectal injuries are uncommon during LRP (0.7%–2.4%), with reports of successful laparoscopic repair when identified.[19–21] Rectal injury can occur following prostatourethral transection if complete posterior dissection was not previously accomplished, leaving the rectum fixed to the posterior surface of the prostate. In this situation, there is an increased risk of rectal injury while attempting to free the prostate because the posterior attachments may now be difficult to view adequately. Another potential location for rectal injury is the lateral border of the rectum that may be injured when performing wide excision of a NVB. Use of a rectal balloon or bougie has been advocated by some authors to help delineate the limits of the rectum and avoid iatrogenic injury.[2,15]

If a rectal injury is suspected, inspect the rectum by transrectal digital inspection or by filling the pelvic cavity with saline and insufflating the rectum with air through a transrectally placed Foley catheter. If air bubbles are detected upon insufflating the rectum, identify the site of injury and carefully inspect the integrity of the surrounding tissues. Close the rectal injury site in two layers and cover with either omentum or perirectal fat.[20] If identified and repaired as described, simultaneous colostomy is generally not required. Patients undergo a bowel preparation before surgery, thus gross contamination of the operative field is minimized. Irrigate the site of repair with copious antibiotic solution, give appropriate parenteral antibiotics to cover gram-negative and anaerobic organisms, and digitally dilate the anus at the end of the operation.

Open Conversion and Reoperation

In the Montsouris series, open conversion to retropubic radical prostatectomy (RRP) occurred in 1.2% of patients and reoperation was required in 3.7%.[17] The indications for reoperation included bowel injury, ureteral injury, hemoperitoneum, epigastric artery injury, persistent anastomotic urinary fistula, and wound dehiscence. In a multi-institutional study of open conversions during attempted LRP, a 1.9% incidence of open conversion was observed during 670 LRP procedures. Most conversions occurred during the surgeons' early experience and with associated contributing patient factors including morbid obesity and prior pelvic surgery. The most common cited reason for conversion included failure to progress, injury to adjacent structures, and hypercarbia.[22] I recommend careful patient selection in a surgeon's early experience with LRP in order to minimize the chance of open conversion; avoid patients with morbid obesity, prior pelvic surgery, and those at high risk for periprostatic adhesions (e.g., prostatitis, multiple prostate biopsies, prior transurethral resection of the prostate).

Anastomotic Strictures

Postoperative anastomotic strictures are uncommon following LRP (0%–3%).[15,17,23] Mobilization of the bladder during LRP allows for a tension-free anastomosis. Equally important is the excellent visualization provided by laparoscopy, which optimizes mucosa-to-mucosa approximation between the bladder and urethral tissues.

Deep Venous Thrombosis

The occurrence of a clinically significant deep venous thrombosis is an infrequent event following LRP (0.4%).[17] This may be attributable to the Trendelenburg positioning, use of sequential compression stockings, lack of venous compression as can occur in open surgery when using a fixed retractor system, and a rapid return to ambulation and normal activities in LRP patients.

Other Complications

Ureteral injury and trocar site hernias following LRP are relatively rare but have been reported.[24] No deaths attributed to LRP have been reported in any study published to date.

Tips and Tricks

Posterior Prostatic Dissection

- Following incision of Denonvillier's fascia, it is critical to completely mobilize the rectum from the posterior aspect of the prostate to avoid subsequent rectal injury, especially during division of the prostatic apex from the urethra.

Bladder Neck Transection

- To help identify the proper plane of dissection between the bladder and prostate, apply anterior traction with the tip of a van Buren urethral sound. Alternatively, use an inflated Foley balloon to help delineate the bladder neck margin.
- With experience, visualization of the subtle transition between the prevesical fat and prostate can help identify the proper plane for bladder neck transection.

Dorsal Venous Complex Ligation

- Ligate the DVC as distal to the prostatic apex as possible to minimize the risk of iatrogenic entry into the apex when dividing the venous complex.
- Divide the puboprostatic ligaments before DVC ligation to allow for greater exposure of the DVC and therefore more distal ligation.

Neurovascular Bundle Preservation

- Preserve the NVBs in either an antegrade or a retrograde direction.
- Recognize that injury to the NVB can occur during many steps of the operation, including dissection of the seminal vesicles, ligation of the prostatic pedicles, transection of the prostatic apex from the urethra, and completion of the vesicourethral anastomosis.
- To optimize quantitative cavernous nerve preservation, it is important to accomplish an anatomic and interfascial dissection of the NVBs. Use fine-tipped laparoscopic dissectors to help define and develop the potential plane between the levator and prostatic fascia.

Continued

Tips and Tricks—cont'd.

Neurovascular Bundle Preservation (cont'd.)

- Thermal energy and electrocautery may be harmful to cavernous nerve function and therefore must be minimized and avoided if possible during dissection near the NVBs.
- Avoid direct manipulation and excessive traction on the nerve bundles.

Vesicourethral Anastomosis

- Use either a single knot running suture or an interrupted suture to accomplish the vesicourethral anastomosis.
- To accomplish a tension-free, water-tight vesicourethral anastomosis, perform the following maneuvers:
  - Have the assistant apply perineal pressure to help reveal the urethra and reduce tension during completion of the anastomosis.
  - Have the assistant grasp the posterior bladder neck to approximate the bladder neck to the urethra when placing the 6-o'clock stitch.
  - Take the operating table out of steep Trendelenburg.
  - Dissect the lateral bladder attachments from the pelvic side wall to further reduce tension at the anastomosis.
- Avoid entrapment of the NVBs when accomplishing the vesicourethral anastomosis.

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CHAPTER 23

Laparoscopic Prostatectomy: Preperitoneal Approach

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Following the inventive works of Raboy and associates[1] and Schuessler and colleagues,[2] laparoscopic radical prostatectomy (LRP) was initially propagated mainly using a transperitoneal approach.[3–5] At the beginning, most laparoscopic centers, including ours, believed that primary transperitoneal access to the seminal vesicles through the Douglas pouch facilitated the technique and increased its safety.[3–6] The procedure was successfully launched in routine clinical practice in France following the pioneering work of Gaston and Piéchaud in 1998 (unpublished series). The transperitoneal approach became predominant worldwide and was considered the gold standard of laparoscopic prostatectomy. However, some concern has been voiced because this technique transformed a traditionally extraperitoneal procedure (open retropubic or perineal radical prostatectomy) into a transperitoneal one, with unique potential complications.[7–9] After 300 transperitonal laparoscopic procedures performed between May 1998 and January 2002, we decided to revisit the extraperitoneal approach. Our preliminary results convinced us to further develop the extraperitoneal approach and to abandon the transperitoneal technique.[10] Between February 2002 and May 2004, we performed more than 300 LRPs via this extraperitoneal approach. Herein we describe our standardized extraperitoneal LRP step by step.

OPERATING ROOM CONFIGURATION AND PATIENT POSITIONING

The surgeon stands on the patient's left side with assistants on the right and left if needed. A camera holder assists with positioning and eliminates the need for an assistant to hold the camera in what is usually an awkward position (Fig. 23–1).

Place the patient in dorsal decubitus with well-protected arms extended along the body. Place the legs in a slight abduction to permit digital rectal examination during the procedure if necessary. After undergoing a standard iodine skin preparation, the patient is sterilely draped and a 20-French Foley catheter is inserted into the bladder (Fig. 23–2).

PROCEDURE

Access to the Preperitoneal Space

Make a midline 3-cm transverse incision 1 cm inferior to the umbilicus. Divide the subcutaneous tissue down to the anterior rectus fascia. Then transversely incise the anterior rectus fascia to identify the inner borders of the rectus muscles separated by the linea alba. Introduce the index finger medially under the rectus muscle and along the posterior rectus sheath (Fig. 23–3). Perform a blunt finger dissection to create a space extending superiorly from the level of the skin incision to the lateral border of the rectus muscle. This space is limited caudally by the arcuate line of Douglas, posteriorly by the posterior rectus sheath, anteriorly by the posterior fibers of the rectus muscle, and medially by the linea alba. Peform the same step on the other side. At this stage, two spaces are created under each rectus muscle and separated by the linea alba.

Creation of the working space is completed with the help of a balloon dilator. This allows visualization of important anatomic landmarks during trocar insertion such as the inferior epigastric vessels and the different muscles of the abdominal wall.

Trocar Placement

Insert trocars 1 and 2 under digital guidance lateral to the rectus muscles (Fig. 23–4). Insert a Hasson cannula (Bluntport; U.S. Surgical, Norwalk, CT) into the initial subumbilical incision, and secure it with stay sutures. Initially perform insufflation at 18 mm Hg. Place a conventional 0-degree laparoscope in the infraumbilical trocar.

Under laparoscopic vision, complete incision of the linea alba to the symphysis pubis. Open the space of Retzius and laterally develop the prevesical space. The anterior aspect of the bladder, the pubic arch, and the external iliac vessels are seen. Laterally develop the preperitoneal space to the epigastric vessels, easily identified on the posterior aspect of the rectus muscles. On both sides, complete the space between the spermatic cord and the epigastric vessels in contact with the abdominal wall. Force back the peritoneum. Under vision, insert two 5-mm trocars in the iliac fossa 3 cm inside the anterior superior iliac spine. Lower insufflation pressure to 12 mm Hg, and set the table in a 20-degree Trendelenburg position.

Pelvic Lymph Node Dissection

When a pelvic lymphadenectomy is necessary, it is now performed. The technique is identical to pelvic lymphadenectomy

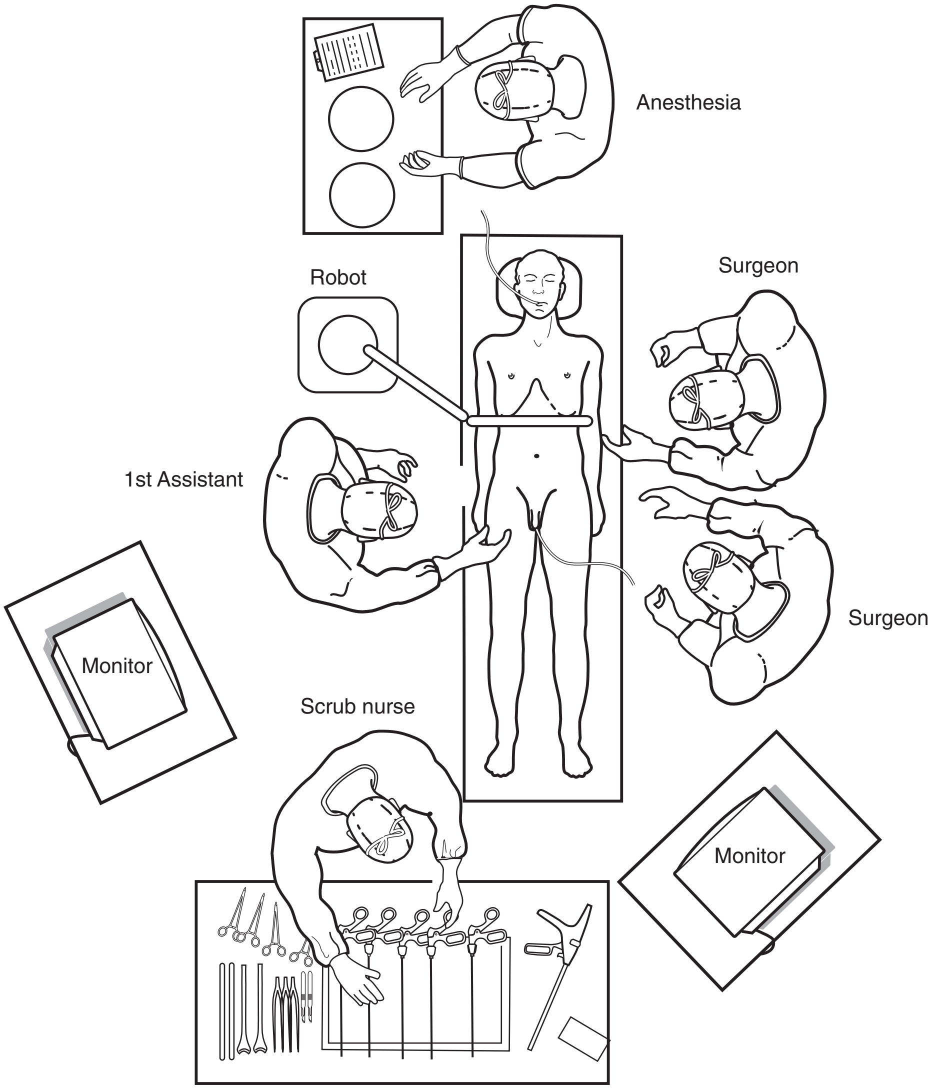

FIGURE 23–1. Typical operating room setup with the surgeon on the patient's left side and monitors placed to allow visualization of the procedure by the entire operating room team.

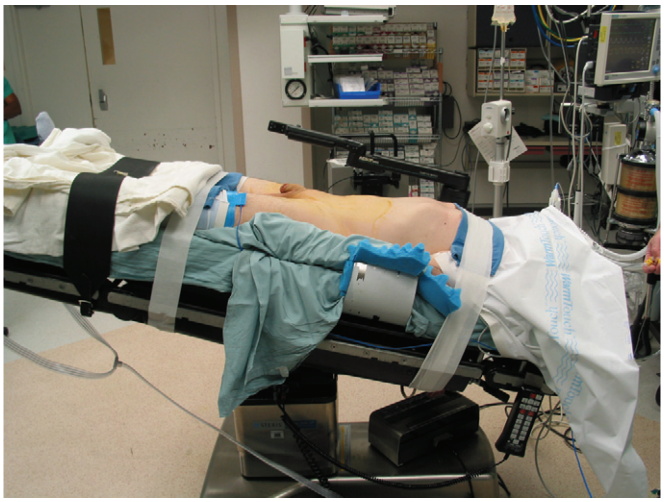

FIGURE 23–2. The patient is carefully secured to the table, allowing a steep angle to assist with dissection.

performed during radical retropubic prostatectomy, with identical anatomic landmarks. Bilaterally dissect the inner border of the external iliac vein from the pubic arch to the vas deferens. An accessory obturator vein is often found near the pubic arch, which may either be preserved or divided between hemostatic clips. Dissect all tissues medial to the external iliac vein. Then laterally retract the vein and complete dissection to see the lateral wall of the pelvis. More posteriorly, the obturator nerve is exposed. Divide the strip of lymph node tissue, starting distally with the lymph node of Cloquet, between clips in contact with the pubic arch. Then pull the lymphatic tissue with obturator nodes upward with a locking grasper. Perform the proximal dissection as far as possible in order to include hypogastric nodes. Pass an endoscopic bag through the left 12-mm trocar, lateral to the umbilicus. Place the two specimens in the bag and send them for frozen section analysis.

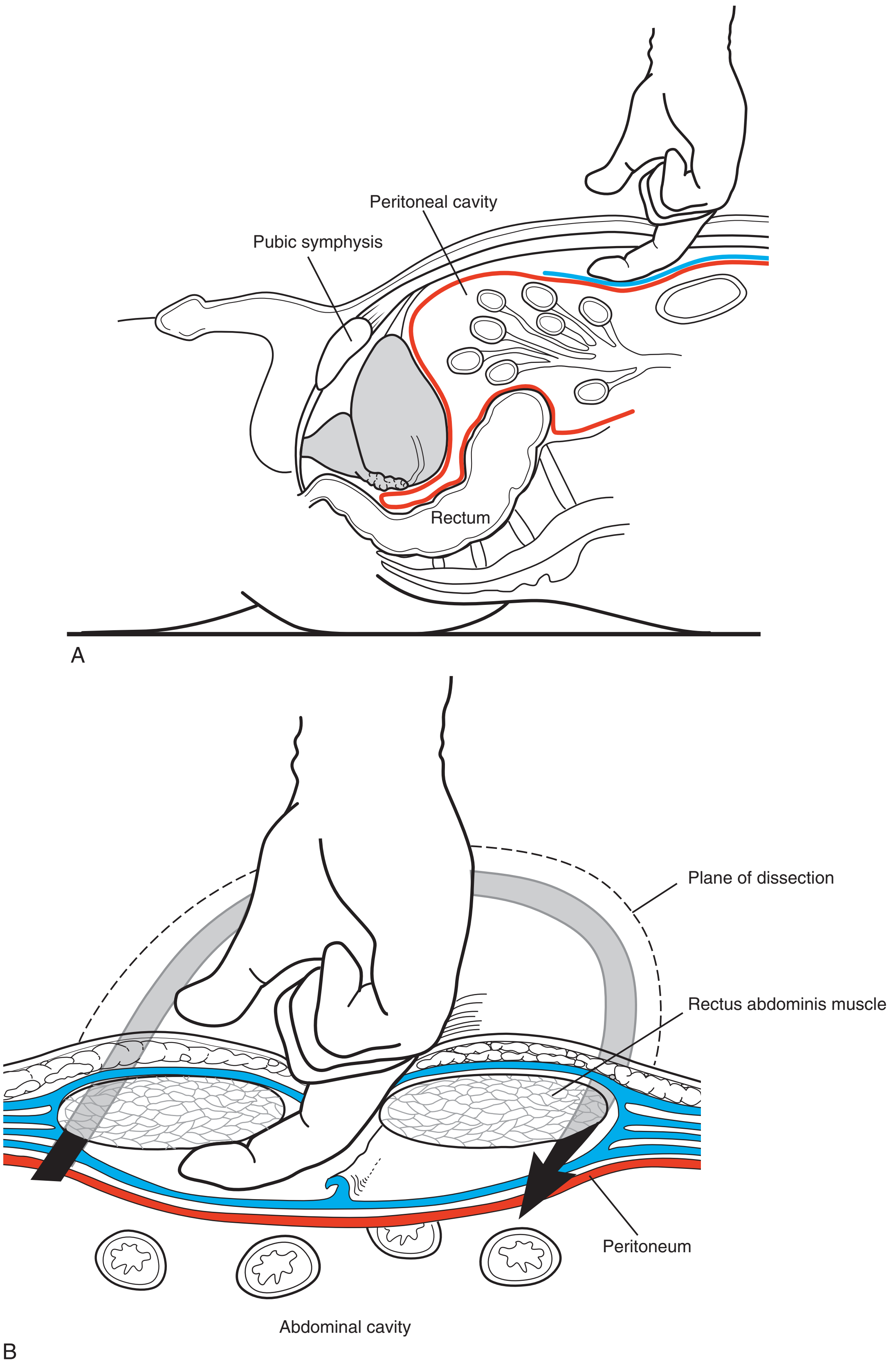

FIGURE 23–3. *A* and *B,* Creation of the preperitoneal space under each rectus muscle with blunt finger dissection.

Incision of the Endopelvic Fascia and Dissection of Santorini's Plexus

Sweep the fatty tissue cephalad and lateral from the endopelvic fascia and from the anterior surface of the prostate. At this point, coagulate and divide the superficial dorsal vein. On both sides, laterally incise the endopelvic fascia toward the puboprostatic ligaments to its line of reflection. Peel the levator muscle attachments off the prostate, and perform the apical dissection to identify Santorini's plexus. Then divide the puboprostatic ligaments in contact with the pubic arch to facilitate dissection of Santorini's plexus. Start the apical dissection to identify the posterior limits of the plexus and the urethra.

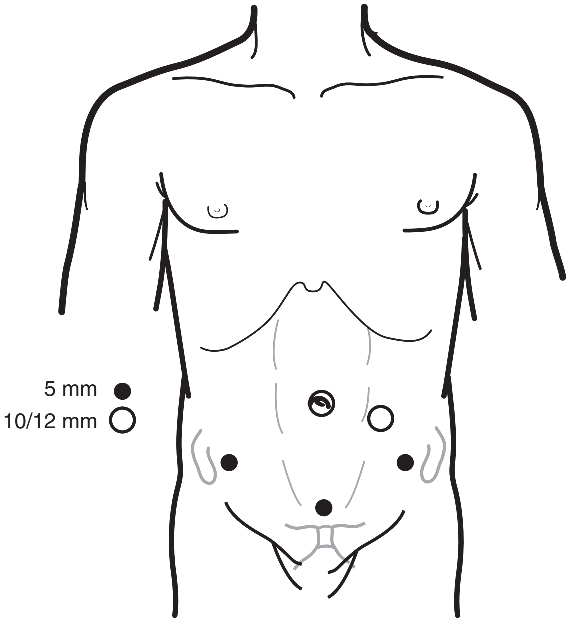

FIGURE 23–4. Trocar positioning.

Transection and Preservation of the Bladder Neck

Identify the bladder neck by palpating the supple bladder in comparison to the solid prostate. Pass a suture and secure it around the superficial tissue at the base of the prostate; leave a long tail for retraction. Insert a sixth trocar and place a toothed grasper on the stitch for upward traction of the bladder neck (Fig. 23–5). Incise the anterior aspect of the bladder neck at the limit between the muscular fibers of the detrusor and the prostatic capsule. When the bladder is opened, deflate the catheter balloon and pull the catheter tip out through the opening. Now place the grasper on the tip of the catheter. The assistant achieves countertraction by securing the catheter with a Kelly clamp placed just beyond the urethral meatus. In this manner, the assistant exposes the posterior edge of the prostate and the posterior bladder neck.

Transection of the bladder neck is completed. Place a locking grasper on the posterior bladder neck, which is retracted cephalad, exposing the anterior layer of Denonvillier's fascia (Fig. 23–6).

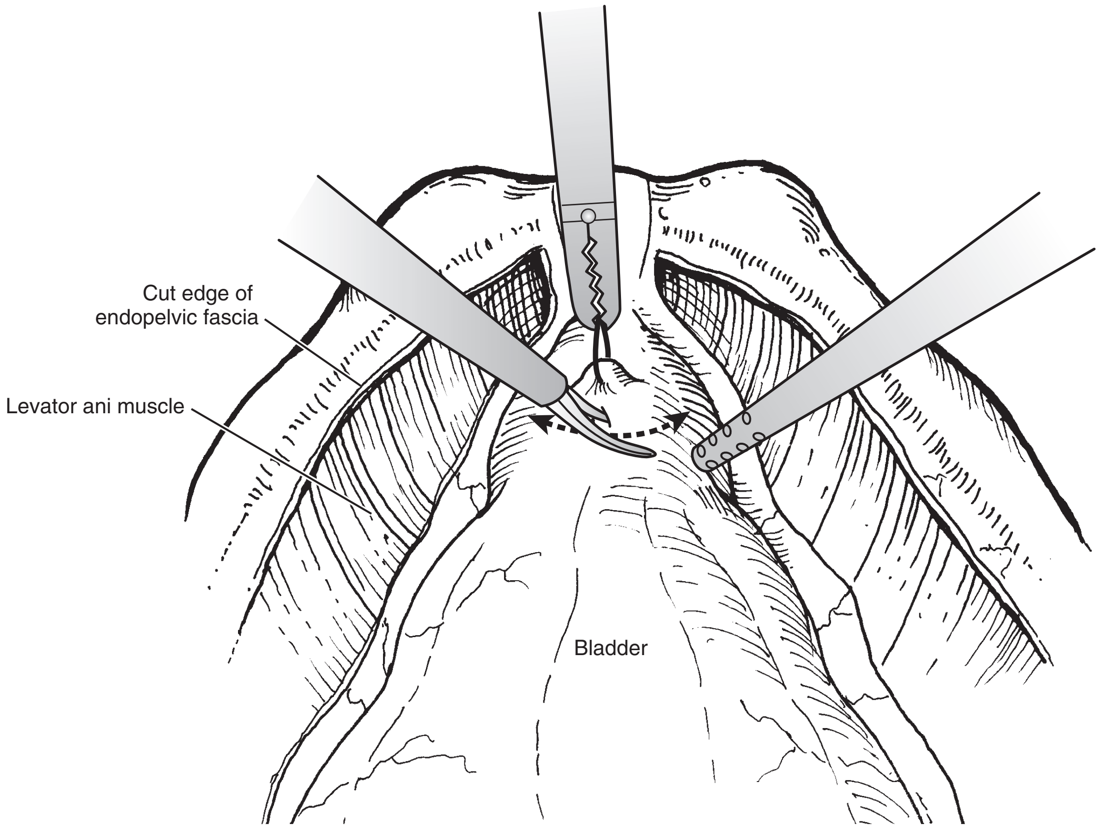

FIGURE 23–5. Suspension of the base of the prostate and section of the anterior bladder neck.

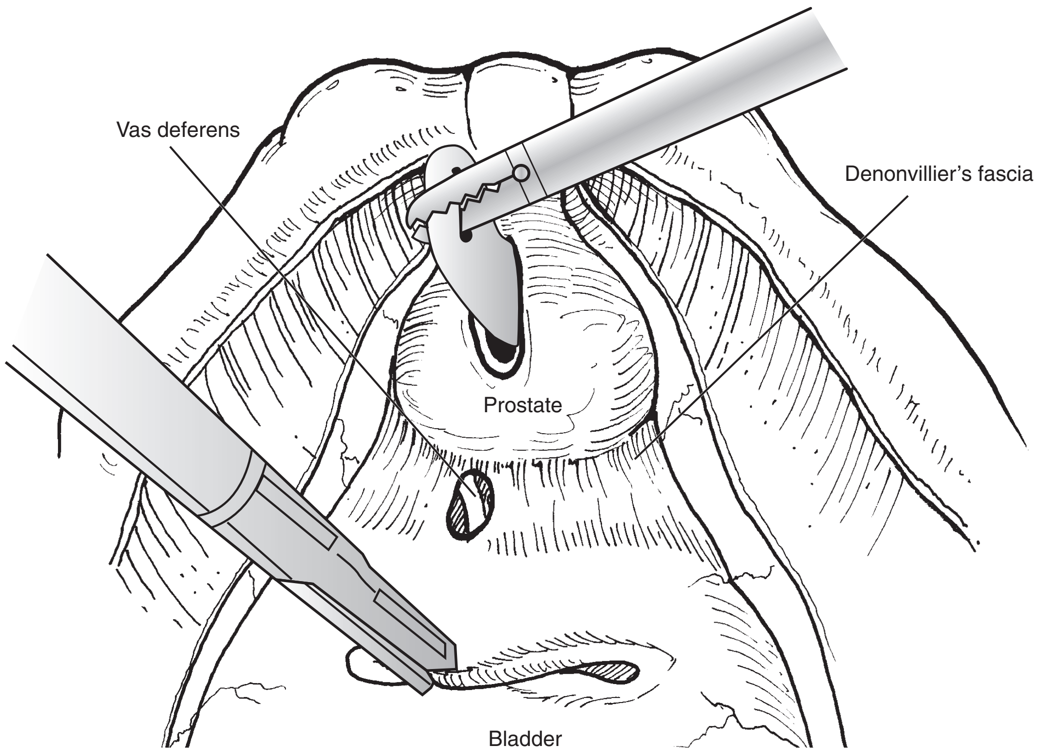

FIGURE 23–6. Division of the posterior bladder neck from the anterior layer of Denonvillier's fascia, which is incised transversely.

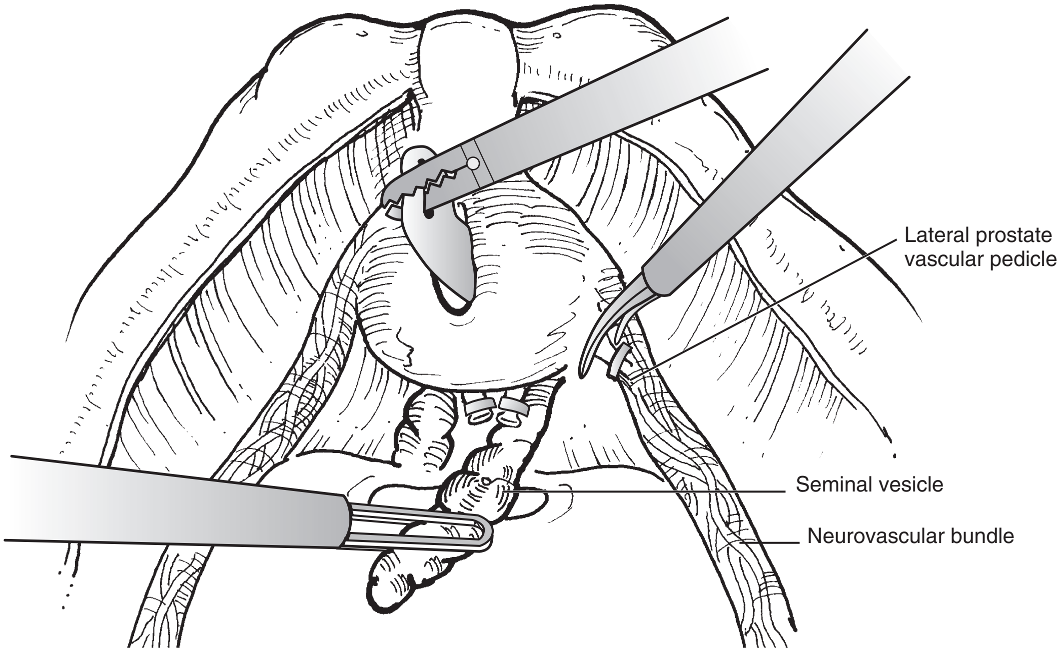

FIGURE 23–7. Exposition of the prostatic pedicles.

Dissection of Seminal Vesicles

Transversely incise the anterior layer of Denonvillier's fascia, which allows visualization of the vasa deferentia. Dissect, clip, and divide the vasa deferentia. Selectively clip and section the vascular pedicle for each structure. After division of each vas deferens, use upward traction on the distal portion of the vas to allow exposure of the seminal vesicles. Two large arteries are typically identified supplying each seminal vesicle from the lateral side (Fig. 23–7). Clip and divide these in a position immediately adjacent to the seminal vesicles. As each seminal vesicle is dissected, grasp these structures and pull them anteriorly. With anterior traction on the seminal vesicles, the prostatic pedicles are exposed.

Transection of Prostatic Pedicles and Preservation of Neurovascular Bundles

To optimize transection of prostatic pedicles and neurovascular bundle preservation, incise the visceral prostatic fascia and the lateral edge of the posterior Denonvillier's fascia in contact with prostatic capsule. Incision of the posterior layer of Denonvillier's fascia reveals prerectal fat and provides a safe plane of dissection (Fig. 23–8). Perform hemostasis of prostatic pedicles near the bundles with clips and near the prostatic capsule with bipolar electrocautery. After transection of the pedicles, open the plane between the neurovascular bundles and prostatic capsule. The last attachments of the bundles are small capsular arteries; divide them in a position immediately adjacent to the prostatic capsule after being controlled with clips. Extend dissection to the prostatic apex. Grasp the vasa deferentia and the seminal vesicles and retract them anteriorly. Medially complete incision of posterior Denonvillier's fascia, and dissect the prostatorectal plane behind the prostate to the rectourethral muscle.

Section of Santorini's Plexus and Section of Urethra

The assistant grasps the suture at the base of the prostate and retracts cephalad to put the apex on tension. Identify the margin between the urethra and dorsal vein complex, and place a figure-of-eight stitch around Santorini's plexus. Section the plexus perpendicularly. Then develop the plane between the plexus and the urethra in an oblique manner caudally. Incise the anterior urethral wall, and visualize the Foley catheter. Push the catheter through the anterior urethrotomy to open the urethral lumen and expose the posterior wall. The assistant retracts and rotates the prostate successively to each side and places the suction tip under the rectourethralis muscle and above the rectum. This maneuver allows a good exposure of the posterior lip of the prostatic apex, optimizing the section of posterior urethral wall and rectourethralis muscle and avoiding positive posterior margins. After incising the urethra and the rectourethralis muscle, place the freed prostate in an endoscopic bag. Extract the specimen through the slightly enlarged infraumbilical port site after removing the Hasson cannula.

Vesicourethral Reconstruction

The Hasson cannula is now reinsected and the abdomen is insufflated. A posterior "tennis racket" reconstruction may be necessary in case of associated large prostatic hyperplasia or previous transurethral resection of the prostate. Perform the urethrovesical anastomosis using the method originally described by Van Velthoven.[11] Prepare the running suture by knotting together two 3-0 Vicryl 5/8 sutures of a total length of 14 cm (Fig. 23–9). Initiate the first running suture by placing a stitch outside-in through the bladder neck and inside-out on the urethra at the 4-o'clock position. Pass another needle outside-in through the bladder neck at the 3-o'clock position. Block the knot behind the bladder neck and place the needle on the right side of the operative field. Initiate the other running suture by placing a stitch symmetrical to the first at the 5-o'clock position. Leave the posterior lip of the bladder 2 cm apart from the urethral posterior wall. Complete the posterior anastomosis with four needle passages outside-in on the bladder and inside-out on the urethra, from the right to the left. When this is achieved, gently pull each suture on an alternating basis to approximate the bladder neck to the urethra. Then place a Foley catheter into the bladder. Peform the anterior anastomosis with the first suture outside-in on the bladder and inside-out on the urethra, from the right to the left. At the 10-o'clock position, knot the two running sutures on the outside of the bladder. Before inflating the balloon of the Foley catheter, make sure that it was not included in the running suture. Fill the bladder with 120 mL of saline in order to verify the integrity of the anastomosis.

Closure

Insert a small suction drain in the left lateral port site and place it in the Retzius space near the anastomosis. Close the anterior rectus fascia. Close skin incisions, and apply sterile dressings.

DISCUSSION

Initial development of the LRP was based on the experience of a few surgeons with transperitoneal laparoscopic access to the prostate and seminal vesicles.[3,6,12] Transperitoneal LRP was successfully introduced in routine clinical practice in France following the pioneering work of Gaston and Piéchaud in 1998 (unpublished series). This approach became predominant worldwide and is considered the "gold standard" of laparoscopic prostatectomy. However, other teams have shown that primary transperitoneal incision of the Douglas pouch is not indispensable for the dissection of the seminal vesicles. Through a transperitoneal access, Rassweiler and colleagues[5] proposed a technical alternative by approaching the Retzius space directly and by reproducing the retrograde technique described by Walsh. Using a purely preperitoneal approach, Raboy and associates[1] performed the seminal dissection after transection of the bladder neck.

Creation of a preperitoneal working space was initially described to perform laparoscopic inguinal hernia repair.[13] Since then, access to the preperitoneal space has been used for many other laparoscopic procedures, which include pelvic lymph node dissection, bladder neck suspension, varicocelectomy, and, more recently, radical prostatectomy.[1,13] Presently, creation of a preperitoneal space is standardized and represents a minimally invasive approach to the prostate. We developed a technique with initial blunt finger dissection, which is a fast, safe, and less costly alternative to the balloon technique.[13] Performing this dissection anterior to the posterior rectus sheath minimizes the risk of inadvertent entry into the peritoneal cavity.

All crucial elements of our previously described transperitoneal technique of LRP[14] are reproduced, and only a few technical points have been modified since we switched to the extraperitoneal approach. Trocar geometry is similar to that previously described in transperitoneal LRP, but a sixth trocar can be introduced during initial space creation. This 5-mm suprapubic trocar does not result in any additional morbidity, but we have found it useful when mobilizing the prostate (see Fig. 23–4). Dissection of the prostate is performed in a traditional anterograde fashion and allows preservation of the neurovascular bundles. During this step, we prefer to use clips rather than any kind of thermal energy to achieve hemostasis.

Based on our favorable experience with two hemicircumferential running sutures when performing the vesicourethral

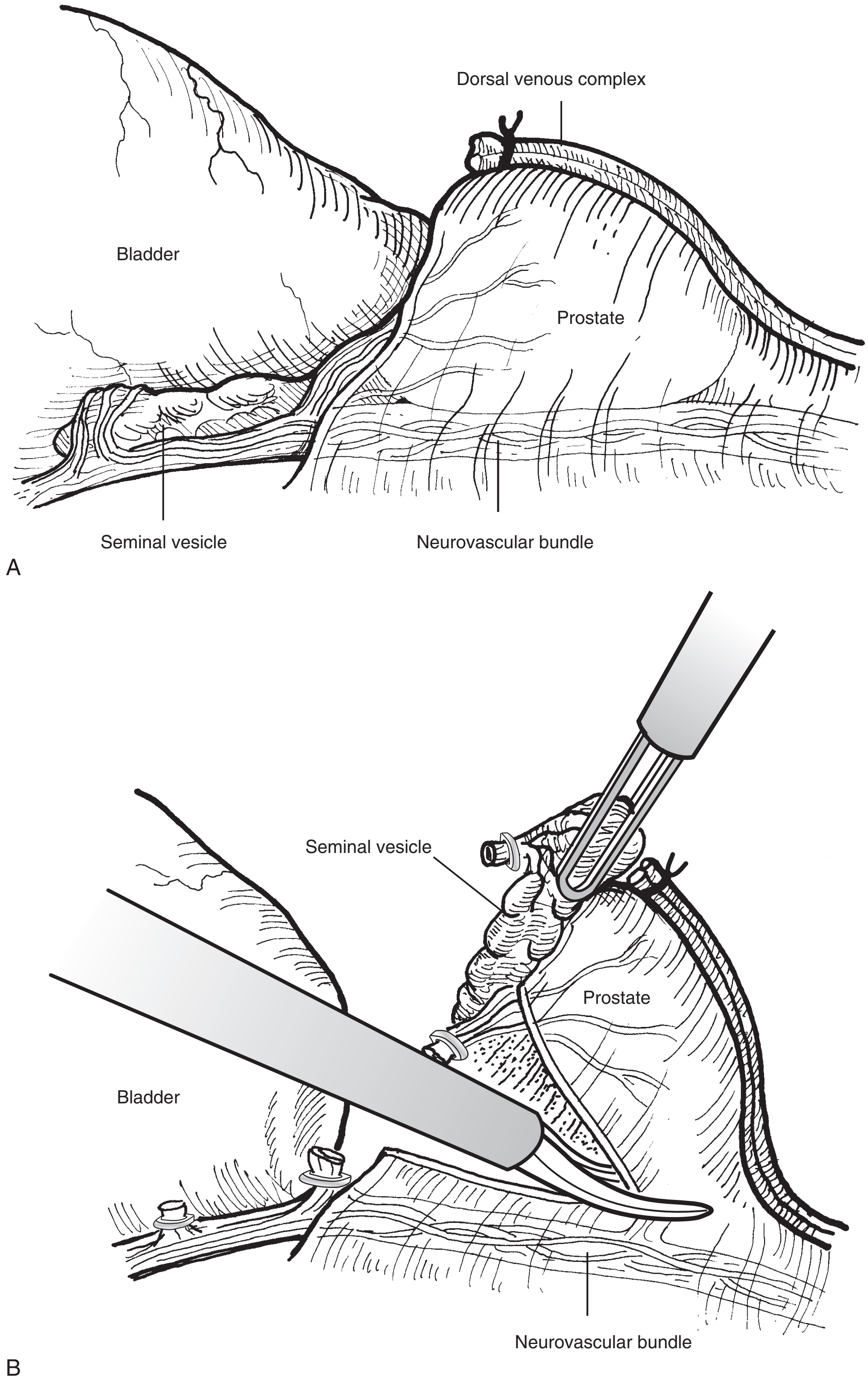

FIGURE 23–8. *A–C,* Section of prostatic pedicles and preservation of neurovascular bundles.

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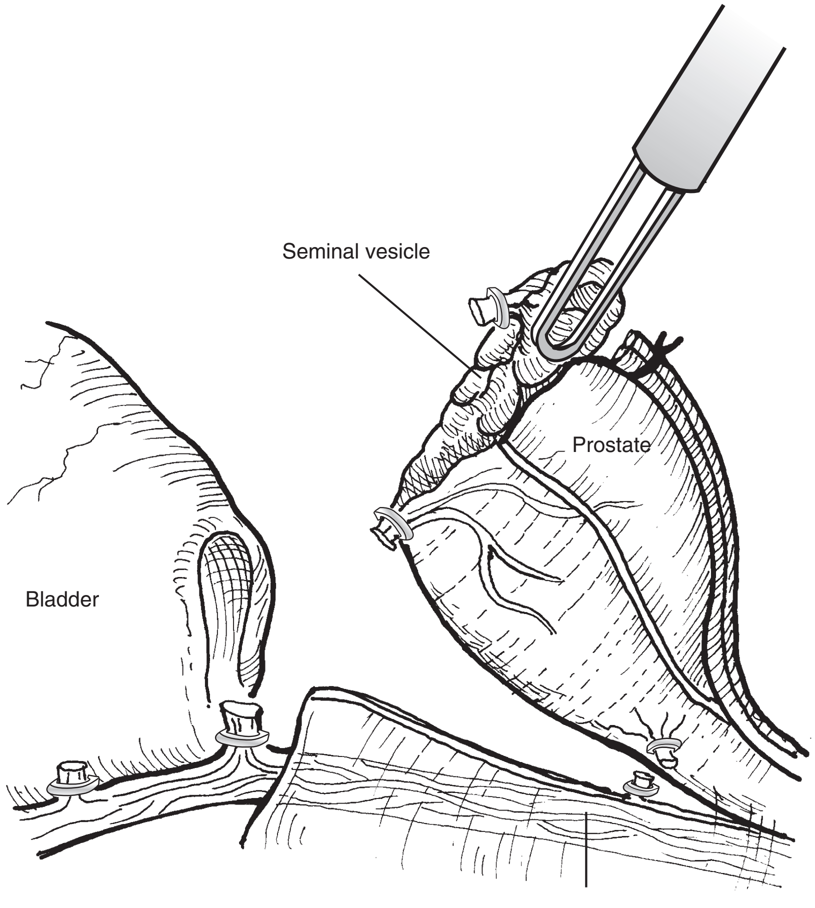

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FIGURE 23–8, cont'd.

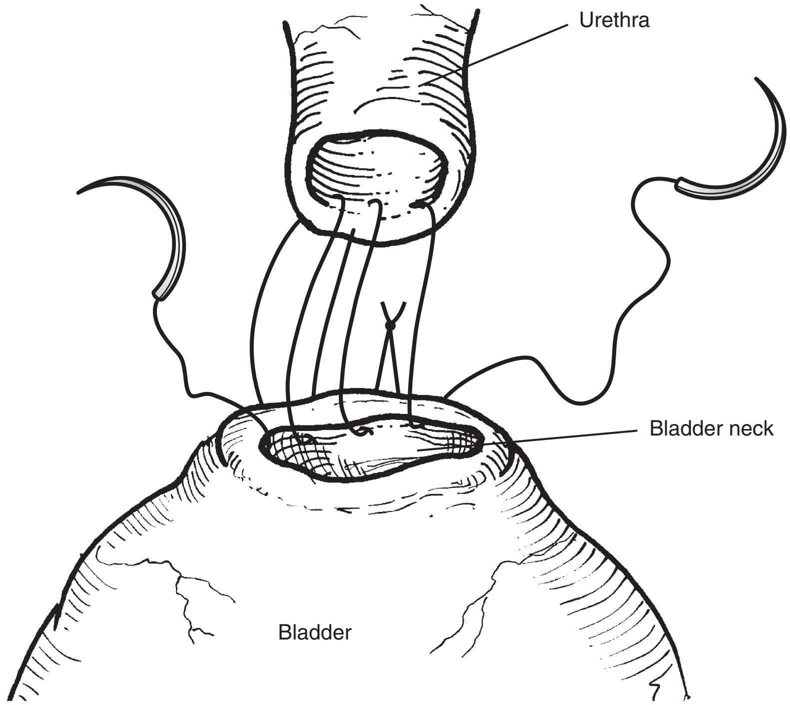

FIGURE 23–9. Vesicourethral reconstruction: needle passages of the posterior anastomosis.

reconstruction,[15] we recently adopted a modification proposed by Van Velthoven and colleagues.[11] The latter technique requires only one intracorporeal knot instead of three and simplifies the control of the posterior half of the anastomosis because all the posterior stitches are placed before approximating the bladder neck to the urethra.

Many teams have now reported that opening of the peritoneal cavity is not indispensable.[8–10,16] In addition, several arguments support the use of a purely extraperitoneal approach. Risks of intraperitoneal injuries during access creation are minimized. Bowel adherences due to previous abdominal surgery do not necessitate any particular modification or precaution when creating the preperitoneal access. Previous inguinal herniorraphy with mesh, while not a contraindication to extraperitoneal LRP, does increase the complexity of prevesical space development, and in these cases, pelvic lymphadenectomy is often impossible.

Other potential advantages of avoiding peritoneal entry are to limit the risk of postoperative ileus and to limit postoperative pain. In comparing extraperitoneal LRP to transperitoneal LRP at our center, measures of perioperative morbidity (postoperative pain, time to full diet) were more favorable when using the extraperitoneal technique.[10] In transperitoneal LRP, some urine and blood inevitably enter the peritoneal cavity during the intervention, causing at least some degree of chemical peritonitis. During the postoperative period, urinary extravasation through the anastomosis is not exceptional and occasionally can become a morbid complication. In 10% to 17.2% of patients, persistent urine in the suction drain can be present for more than 6 days due to anastomotic leakage.[17–19] To what extent such a urinary leak can communicate with the peritoneal cavity is unclear; however, this mechanism can lead to more severe complications. In transperitoneal laparoscopic series, prolonged ileus attributed to anastomotic leak was reported in 2.8% to 8.6% of cases.[7,19] In a large series, secondary anastomotic leakage was diagnosed after catheter removal in a context of acute pain, acute urinary retention, and peritoneal irritation syndrome in 2% of patients.[17] Ileus, anastomotic leak, and hemoperitoneum are all classified in the second group of the complication grading system proposed by Clavien and colleagues for laparoscopic surgery.[17,20] Grade II complications are "potentially life threatening but without residual disability."

Establishing the complexity and technical difficulty of a surgical intervention is mostly a subjective exercise. However, indirect data suggest that the extraperitoneal approach may provide a simplification of laparoscopic prostatectomy. Presently, there are only a few comparative studies dealing with transperitoneal versus extraperitoneal LRP.[10,21] Uniformly, all these studies have shown a statistically significant decrease in operative time ranging from 10 to 54 minutes, which suggests that extraperitoneal LRP may be a more straightforward procedure.

Furthermore, especially in the learning curve phase, open conversion to radical prostatectomy can be performed in the familiar environment of the retropubic space. But even without the necessity of conversion, for those who begin performing laparoscopic prostatectomy, complications (leak or hemorrhage) will be also easier to manage when using the extraperitoneal approach.

The first results of extraperitoneal LRP in terms of oncologic cure and preservation of continence and potency do not seem to differ from those of transperitoneal LRP.[10,16,22] This technique seems reproducible, with possibly a decrease in operative time.[10,21,23] These advantages are essential in a university center like ours, especially because teaching LRP is a complex process requiring a large number of cases (>50) to reach the plateau of a learning curve.[24] Using an extraperitoneal approach, the first two steps do not require a long experience, and the rest of the procedure uses familiar anatomic landmarks, which are the same as for retropubic access. Furthermore, compared with the transperitoneal approach, this technique needs only one space of dissection instead of two. In our experience, teaching LRP with this technique has also become easier. Also, we believe that the extraperitoneal approach may improve the learning curve of LRP, which is essential to its development.

Despite all these arguments, unanswered questions remain. Obviously, the primary goal of radical prostatectomy is oncologic cure and preservation of urinary continence and potency. Attempts to decrease operative time and perioperative morbidity should not outrival these principles. The task that remains is to prospectively compare the two techniques considering all these outcome variables in order to objectively determine the relative merits of each of these approaches.

SUMMARY

LRP is undergoing a continuous technical development. At our center, the extraperitoneal approach appears to be the logical evolution for LRP because it combines the advantages of laparoscopic surgery and retropubic access and significantly reduces operative time. This technique is well standardized, but further evaluation of long-term results is necessary. We believe the extraperitoneal technique may shorten the learning curve of LRP.

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CHAPTER 24

Robotic Prostatectomy

David I. Lee

Prostate cancer is the most commonly diagnosed cancer in men. The American Cancer Society estimated that 232,090 cases would be diagnosed in the United States in 2005. Radical prostatectomy is a mainstay of treatment of organ-confined disease. In 2001, Abbou and colleagues[1] reported the first series of robotic assisted laparoscopic prostatectomy. The da Vinci Surgical System (Intuitive Surgical, Sunnyvale, CA) was used in this report and is the platform that is the most widely used for radical prostatectomy. Following this report, Menon[2] accelerated the acceptance of the procedure by demonstrating a shortened learning curve over standard laparoscopic approaches while maintaining excellent outcomes. The growth of robotic prostatectomy far outstrips that of standard laparoscopic prostatectomy, likely due to the improved ergonomics, three-dimensional vision, and improved instrumentation. These factors combine to improve the ability of even experienced laparoscopic surgeons.[3]

Briefly, the robotic platform consists of a surgeon's console and a patient-side tower. The robot tower is draped with sterile plastic and fitted with sterile attachments that are "docked" to preplaced trocars specially designed for the robot. Once the instruments are attached, the surgeon sits down at the console and remotely controls the robotic instruments. Some robots are equipped with three arms: one for the camera and two working instruments. However, others have an additional instrument arm, or fourth arm. A tableside assistant helps with suction-irrigation, retraction, and exchanging instruments. This chapter describes our technique for robotic-assisted laparoscopic radical prostatectomy with a four-arm robotic system. Certainly, most of the actions performed by the fourth arm can be replicated by the tableside assistant surgeon.

INDICATIONS AND CONTRAINDICATIONS

Nearly any patient who can be considered for an open radical prostatectomy is a candidate for a robotic procedure. There are certain patient factors that predict a more difficult case. Obesity, defined as a body mass index of 30 kg/m^2 or more; prostate size greater than 80 g; and intra-abdominal adhesions almost certainly increase operating room time, particularly during the learning curve. As a surgeon's experience increases, these difficulties are minimized such that even patients whose weight approaches 300 pounds and whose prostates are as large as 250 g can undergo the robotic procedure.

PATIENT PREOPERATIVE EVALUATION AND PREPARATION

After the informed consent process, evaluate the patient with standard laboratory work, a urinalysis and culture if indicated, a chest radiography, and an electrocardiogram. Blood-thinning medication is halted appropriately.

On the night before the procedure, the patient takes a dose of magnesium citrate. In the morning, the patient arrives at the hospital, is administered parenteral antibiotics, and compression stockings are placed.

OPERATING ROOM CONFIGURATION AND PATIENT POSITIONING

The room layout is critical because the robot console and tower are large pieces of equipment. Preoperative planning is essential to allow all members of the operative team to have sufficient room to work and view the monitors, for all appropriate cords to reach the proper connections (e.g., cautery, insufflation tubing), and for the robot to have sufficient room to move toward and away from the patient (Fig. 24–1). The robot must be brought in toward the patient's feet; therefore, there must be sufficient room for this to occur. Additionally, because it is attached to the tower via several cables, the console must be in relative proximity to the tower. The light source and the camera are on a robot-specific equipment tower that is brought in close to one side of the patient-side tower once positioning is complete. Another monitor is brought in on the other side.

My preference is to place the assistant surgeon so that his or her dominant hand (usually right) manipulates the suction device and thus is on the left side of the patient. The scrub nurse stands on the right side of the patient with the sterile back table. A Mayo stand is placed over the patient's face; it is used as an instrument stand and protects the endotracheal tube from dislodgment by camera movements.

Bring the patient to the operating suite, where general anesthesia is induced. Place the patient on a bed that has either split leg positioners or stirrups; the split leg positioners are preferred. Split the legs about 30 degrees away from each other and then rotate them downward in relation to the bed, also about 20 to 30 degrees (Fig. 24–2). This allows the robot tower to be moved sufficiently close to the patient.

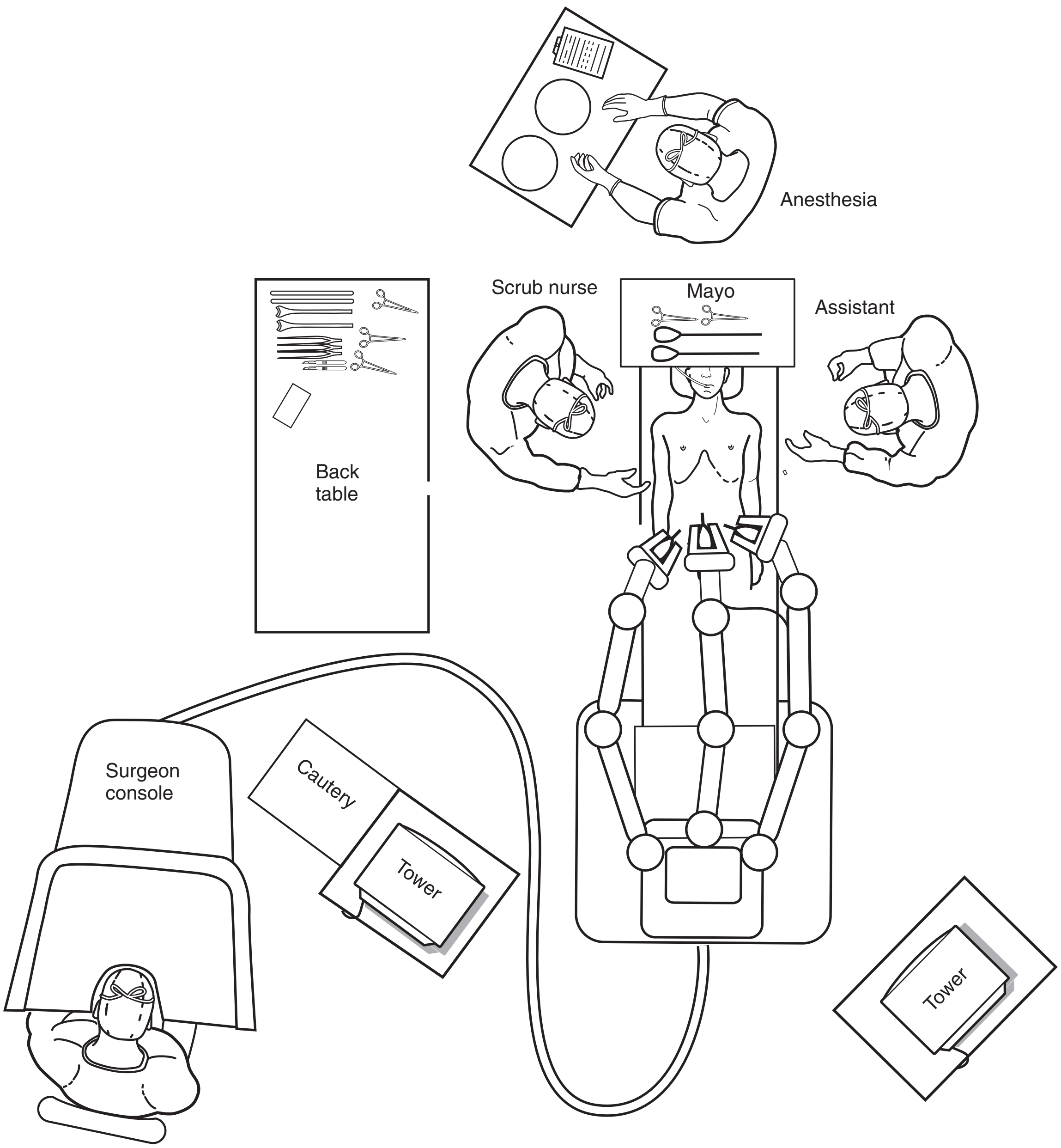


FIGURE 24–1. Typical room setup for robotic prostatectomy. Adequate room for rolling the robot to and away from the table makes an effective setup. A fourth arm can be mounted in the middle front portion of the main post. This can be placed on either side of the patient depending on surgeon preference.

Very loosely wrap the legs with blankets and tuck the arms. I prefer to tuck using a sled on the arm opposite the robot's fourth arm and using only foam padding and the drawsheet on the right. This enables easier docking and improved mobility of the fourth arm of the robot. A sled positioned on the fourth arm side may obstruct movement of the arm outside the patient. This will be noticed most when the arm is moved upward inside the patient. The outside of the robot will move downward and strike the sled, thereby limiting the range of motion.

Place the patient in an exaggerated Trendelenburg position. I do not typically use shoulder rolls because tucking the arms and lowering the legs sufficiently anchors most patients and protects them from sliding.

TROCAR PLACEMENT

Once the patient is anesthetized, prepare and drape the patient in sterile fashion. Place a 22-French Foley catheter to allow gravity drainage. Use a Veress needle to obtain pneumoperitoneum; alternatively, use a Hasson approach, if desired. Once adequate insufflation has been obtained, place the ports as shown in Figure 24–3, beginning with the midline supraumbilical trocar. I prefer to use the Ethicon 12-mm dilating trocar (Ethicon Endo-Surgery, Cincinnati, OH) for the camera port. The rigidity of this cannula is essential because significant torque against the camera trocar can occur. Any bend of the cannula will be transmitted against the

FIGURE 24–2. Typical patient position for robotic prostatectomy. Simply tucking the arms and lowering the legs on spreader bars prevents patients from sliding due to Trendelenburg positioning. Shoulder bolsters and rolls are not typically used.

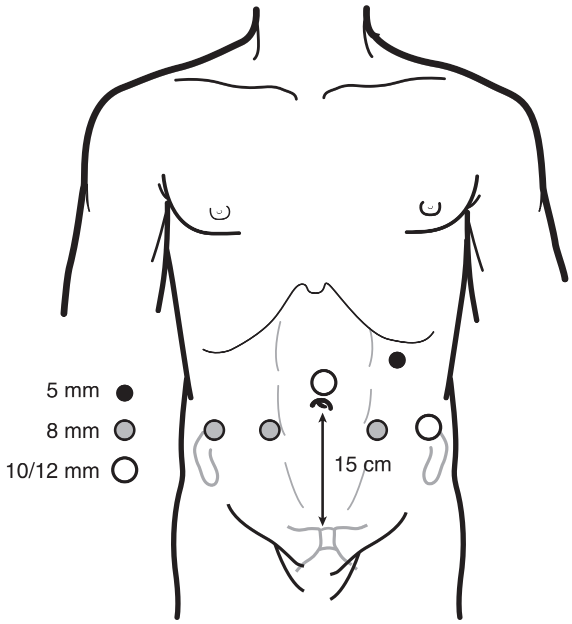


FIGURE 24–3. Possible four-arm robot port placements. The lateral 8 mm may be removed if a three-arm robot is used.

shaft of the camera and free movement of the lens may be hampered.

Insert the camera and inspect the abdomen for any adhesions or entry injury. Place the remaining ports under direct vision. Meticulously place these ports (see Fig. 24–3). The robot port site should be no more than 18 cm from the pubis because the instruments have a maximum working length of 25 cm.[4] It is my practice to precisely measure the distances for each port rather than estimating by hand width. Initially, use a marking pen to identify the top of the pubis. Place a 12-mm mark just above the umbilicus for the camera port. Draw another mark 15 cm cephalad from the pubis. Then, locate the robot trocar sites so that they are 15 cm above the pubis mark and 8 cm from the lower midline mark. This ensures sufficient working room between the arms of the robot and sufficient reach so that the tips of the instruments will reach to the membranous urethra. Difficulty with arm collisions can become greatly magnified if the trocar sites are too close together.

The straight line that is created by the first two robot ports then allows placement of the fourth arm port and the assistant's 12-mm port. Follow the straight line 8 cm lateral to each of the robot ports; place the 12-mm port on the side of the assistant, that is, on the left side for a right-hand dominant assistant. Place the fourth arm port on the contralateral side, if this port is present. Finally, place a 5-mm port 8 cm on a diagonal line cephalad and lateral to the camera port. This can lie very close to the costal margin on smaller patients. This high position is essential, however, to provide working room for the hand of the assistant; too low a placement can trap the assistant's hand between the robotic arms. Once the ports are placed, move the robot into position between the legs of the patient. Bring the camera and the yellow and green arms of the robot in over the patient and dock it. Bring the red or fourth arm in underneath the leg of the patient and then raise it until it just touches the underside of the leg holder and is docked to the lateral robot port. Once all of the instruments are introduced, sit down at the robotic console.

PROCEDURE

Dropping the Bladder

My lens preference is a 0-degree lens at the outset. Be sure to confirm that the lens setting on the robot is indeed set to "straight" rather than "angled." The permanent spatula cautery and bipolar grasper are the primary working instruments at this stage. Set motion scaling to "fine" initially; however, as the console surgeon gains more experience, motion scaling may be turned off. The procedure can be initiated by either dissecting out the seminal vesicles or dropping the bladder first. I prefer to simply drop the bladder.

Inspect the peritoneum to reveal the internal inguinal rings and the medial umbilical ligaments. Incise the peritoneum just lateral to the ligaments and carry the dissection laterally to a spot immediately anterior to each internal ring. Keep the incisions superficial so as not to injure the epigastric vessels. Bladder irrigation via the Foley catheter can help define the limits of the bladder; however, incisions created lateral to the medial ligaments obviate the possibility of bladder injury. Carry the two lateral incisions along the ligaments medially and superiorly until the reach of the instruments becomes limited.

As the bladder flap is created, the whitish fibers of the transversalis fascia come into view. Follow these fibers caudally; once these thin out, follow the contour of the abdominal wall inferiorly until the pubis is seen. Clean the pubis of connective tissue, and medially bunch the fat medial to the arch of the pubis off the prostate toward the apex. This move also cleans off the endopelvic fascia of overlying adipose. The superficial dorsal vein is contained within this fat; use bipolar cautery to seal this vessel, if needed. After the vein is divided, roll the fat away from the apical portion of the prostate toward the base. If there is a significant amount of fat, excise and remove a large portion of it. This can be especially helpful later on during the anastomosis.

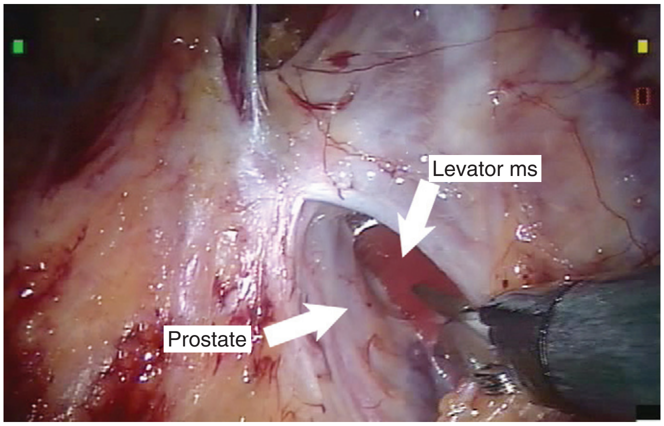


FIGURE 24–4. Clear definition of levator side wall from prostate is key to a bloodless dissection. The lowest point of the incision should expose a small amount of perivesical fat. This is a signal that the incision has been taken sufficiently proximal. ms, muscle.

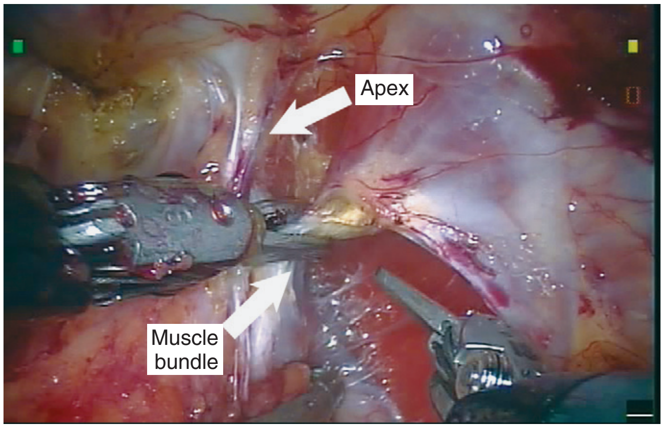


FIGURE 24–5. This very consistent bundle is usually cauterized with bipolar energy before division from the prostate to help minimizing bleeding.

Entering the Endopelvic Fascia

Sharply incise the fascia laterally so that the underlying prostate capsule and levator muscles are seen (Fig. 24–4). Initiate this incision in the region of the prostatovesical junction and then carry it toward the apex of the prostate. This helps avoid bleeding from the vessels that are consistently present more apically.

Inferior and lateral to the apex of the prostate, a band of muscle is consistently present that usually encases a vein or artery or both. Remove this band from the prostate by first applying bipolar energy to the bundle very near its insertion to the prostate and then dividing it with scissors (Fig. 24–5). With the prostate apex clearly in view, thin the fascia overlying the dorsal venous complex (DVC) in order to define the junction between the vein and the urethra. Once this is achieved, divide the DVC.

Ligation of the Dorsal Venous Complex

The DVC can be handled by one of several methods; the most common is either suture ligation or stapling. If suturing is to be performed, a 0-Vicryl on a CT-1 needle is typically used to place a figure-of-eight around the DVC. Often, a back-bleeding suture is also placed toward the prostate. Once tied, the DVC can be divided at this point, but many surgeons leave this intact temporarily until the urethra is approached later during the case. I prefer to staple the DVC using the Ethicon laparoscopic stapler with a 45-mm cartridge length and 2.5-mm staple leg length. (Ethicon Endo-Surgery). Introduce the stapler into the field through the lateral 12-mm port. From this angle, place the anvil portion of the stapler on the contralateral side so that the black lines just pass the edge of the DVC (Fig. 24–6). Use of a 22-French Foley helps prevent stapling of the urethra because this diameter catheter is very difficult to fit inside the open jaws of the stapler. Clamp the stapler to the locked position and hold it for 10 seconds before firing. This provides tissue compression, which improves staple formation and hemostasis. Once divided, there should be a small line of stapled tissue left, which can be easily divided later. If there is any bleeding or if the staple line separates, use a small figure-of-eight stitch with a 3-0 Vicryl to stop the remaining bleeding.

Prostatovesical Junction

Switch the lens to a 30-degree down lens to provide a more familiar downward view of the prostatovesical junction. The tableside assistant then slowly pushes in and withdraws the Foley catheter. The prior removal of superficial fat usually allows easily visualization of the catheter balloon. Once the location of the junction is firmly in mind, perform sharp dissection with either cautery or scissors just cranial to the junction (Fig. 24–7). Carry the dissection from medial to lateral; if it is done carefully, the large superficial veins coursing from the prostate to the bladder can be lifted off the underlying structures, minimizing bleeding. The lateral junction between the prostate and the bladder is then visualized.

From this point, carry the dissection from lateral to medial to thin out the attachment fibers. Enter the bladder neck, and withdraw the balloon of the Foley catheter. Grasp the catheter through its eye with the fourth arm and pull the catheter anteriorly. Leave the posterior lip of the bladder neck intact while dividing the remaining lateral fibers that are attaching the bladder to the prostate. In many cases, this dissection can be carried posterior to the bladder neck, thereby preserving the circular fibers of the bladder neck, which may aid in early continence recovery.

Finally, completely divide the bladder neck. Inspect the bladder neck to ensure that there is sufficient distance from the ureteral orifices for later suturing and to identify any need for later bladder neck reconstruction. Indigo carmine is not routinely administered during this dissection.

Seminal Vesicles and Vas Ligation

After the bladder neck is divided at the proper level, note a whitish fibrous layer. Divide this layer; in some patients, it is quite thick. Immediately posterior to this layer is a layer of fat overlying the ampulla of the vas. It is helpful at this point of the dissection to observe the general size of the prostate (Fig.

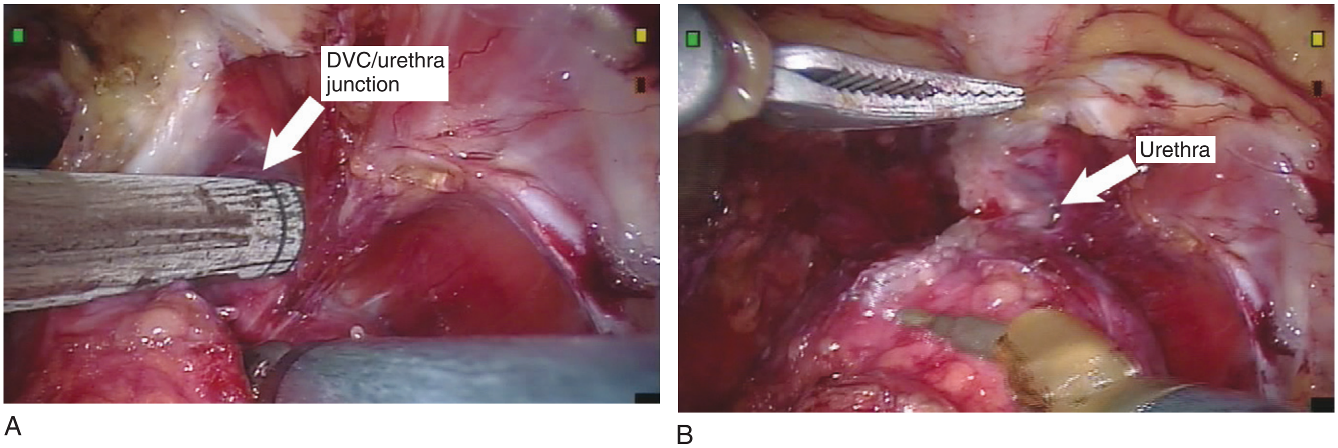


FIGURE 24–6. *A* and *B,* The second black line is placed at the junction between the dorsal venous complex (DVC) and urethra. If this is not performed the residual staple line is more likely to split slightly and bleed.

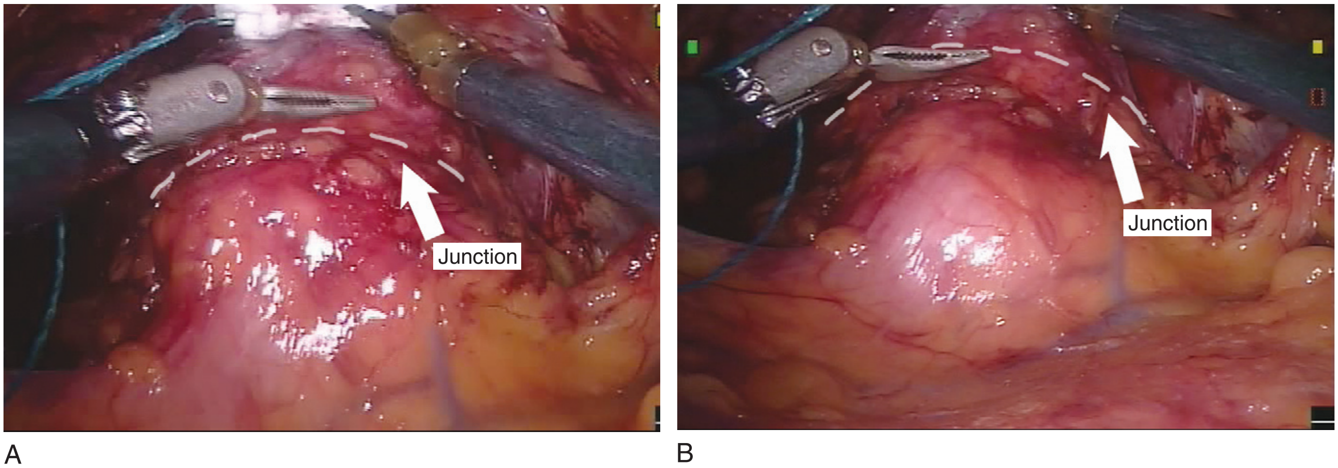


FIGURE 24–7. *A* and *B,* Movement of the Foley balloon (inflated to 10 mL) in and out greatly aids in the identification the prostatovesical junction. If an eccentric movement of the catheter balloon is observed, a large median lobe is likely present.

24–8). If the prostate is very large or has a significant median lobe component, then the angle at which this layer is divided is much steeper than if the prostate is small. If this is not appreciated, for example, in the case of large prostate, a portion of the prostate may easily be shaved off as one is searching for the vasa if too shallow a plane is taken.

Once the ampullae are identified and dissected, excise long sections. Do this by dissecting sufficient tissue away from the lateral sides of the vasa and then grasping one firmly with the fourth robotic arm. Use upward traction to bring more of the vas into better view, then further dissect it (Fig. 24–9). Use the long excised remnants as a pledget during the anastomosis. Once the vasa are divided, pull the stumps on the prostate upward using the fourth arm to visualize the medial aspects of the seminal vesicles. The bulk of the vasculature to the seminal vesicles courses laterally; thus, medial dissection is easier and allows the seminal vesicles to be rolled upward and medially. Often, very little dissection then needs to be performed laterally. My preference is to use a bipolar grasper and scissors during this dissection to allow precise division of the vessels, minimizing any possible damage to the nearby neurovascular bundles.

Prostate Dissection

Grasp the stumps of the vasa with the fourth arm and use them to pull the prostate upward toward the pubis and out of the pelvis toward the umbilicus. Once proper traction is obtained, note the posterior contour of the prostate (Fig. 24–10). Incising Denonvillier's fascia precisely at this point helps to minimize any chance of injuring the rectum or incising into the prostate. Divide the fascia along the posterior surface of the prostate, and gently push down the fat overlying the rectum, away from the prostate. Definitely identify the posterior capsule of the prostate, and carry this plane of dissection toward the urethra as far as can be reached. In men with smaller prostates, often the fibers of the rectourethralis can be identified. Once the rectum has been definitely mobilized, either resect or spare the cavernous nerves. For a non–nerve-sparing procedure, the plane adjacent to the rectum can be continued laterally. This provides a large margin around the base and lateral portion of the prostate (Fig. 24–11).

For a nerve-sparing procedure, closely follow the capsule of the prostate from medial to lateral. First, either the fourth arm

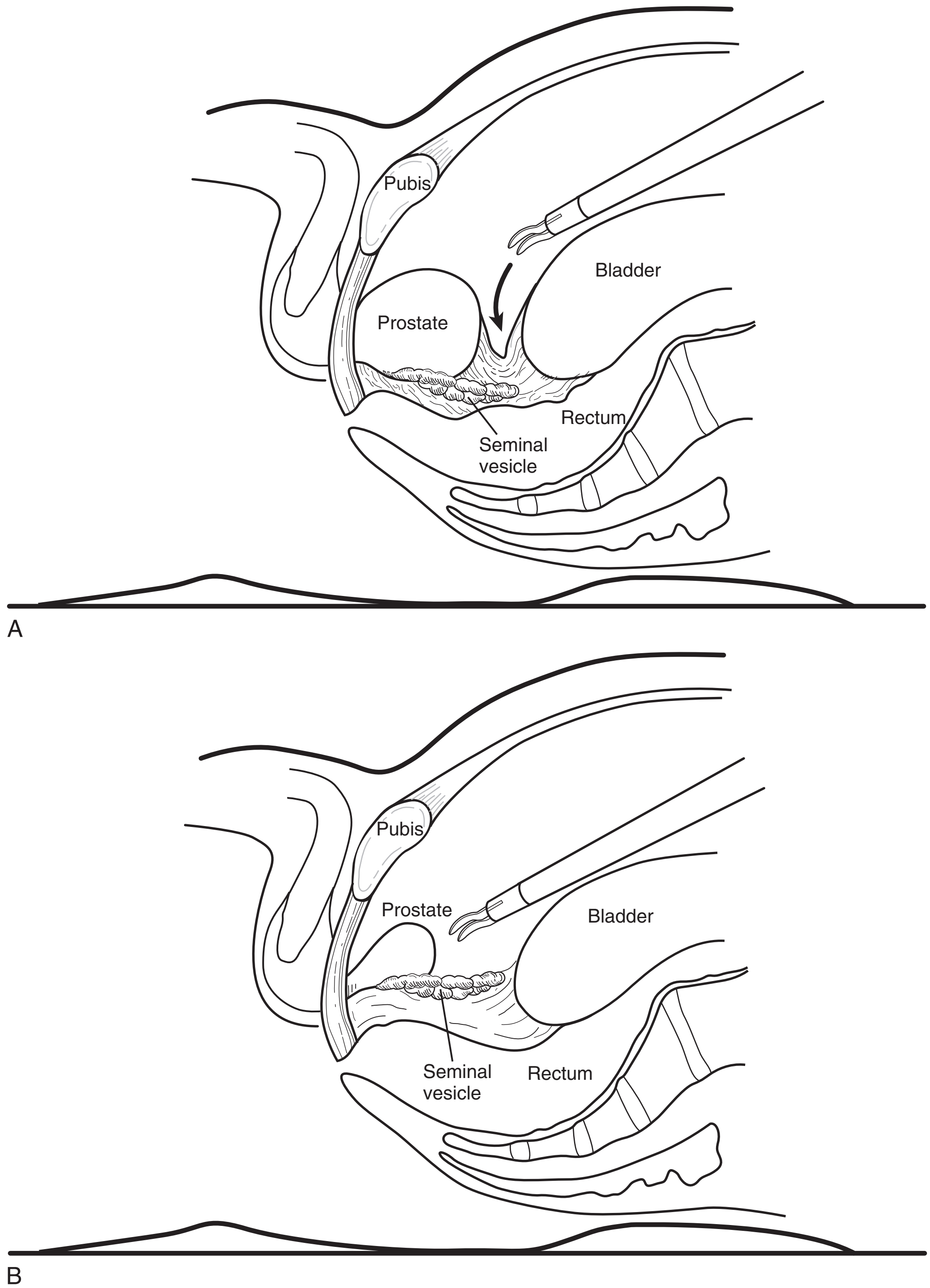


FIGURE 24–8. *A,* Large prostates require a much steeper plane to find the ampulla of the vas. *B,* Smaller prostates require a much shallower plane.

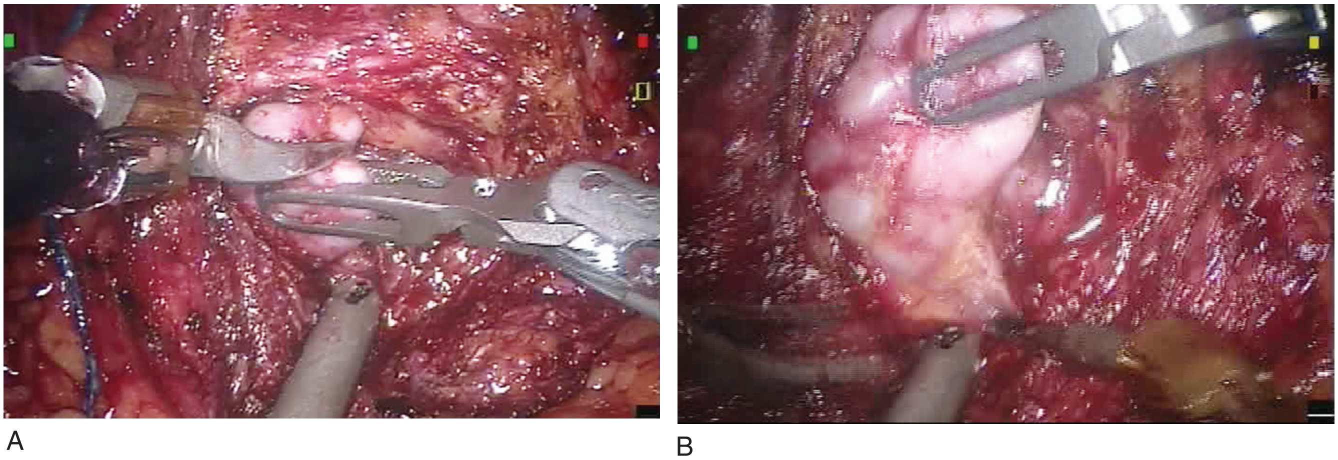


FIGURE 24–9. *A,* The Prograsp instrument in the fourth arm acts as an excellent retractor especially during the course of the vas dissection. As movement of the fourth arm is performed one must be aware to not strike the pubic arch with the wrist of the instrument. *B,* Elevation of the seminal vesicle allows identification of its insertion into the prostate completing the seminal vesicle dissection.

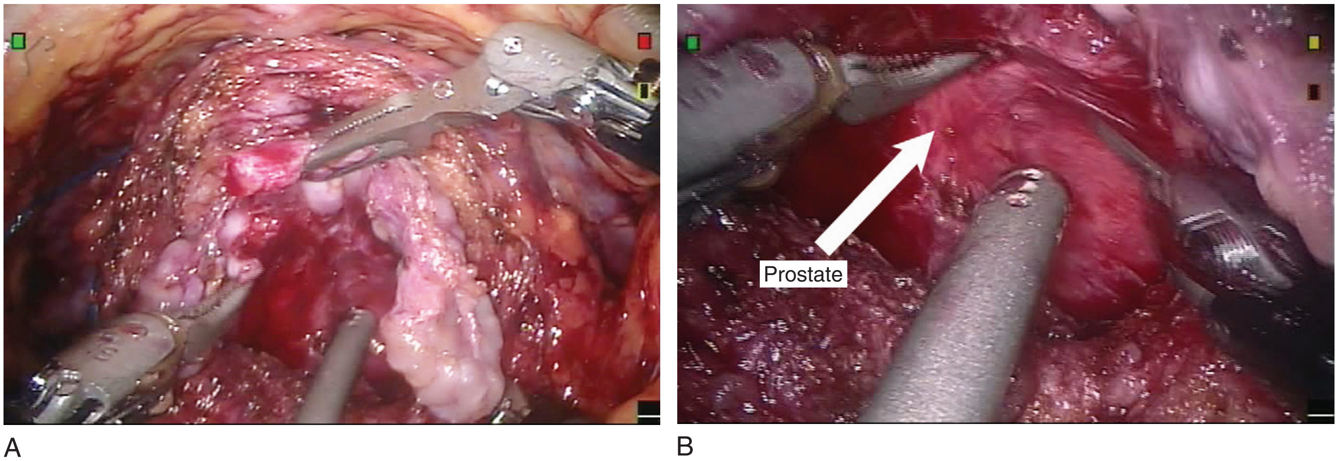


FIGURE 24–10. *A,* Grasping both vas stumps and retracting anteriorly helps to delineate the posterior plane on the prostate. *B,* Incision directly on the curve demonstrated is a reproducible landmark if proper anterior traction of the prostate is obtained.

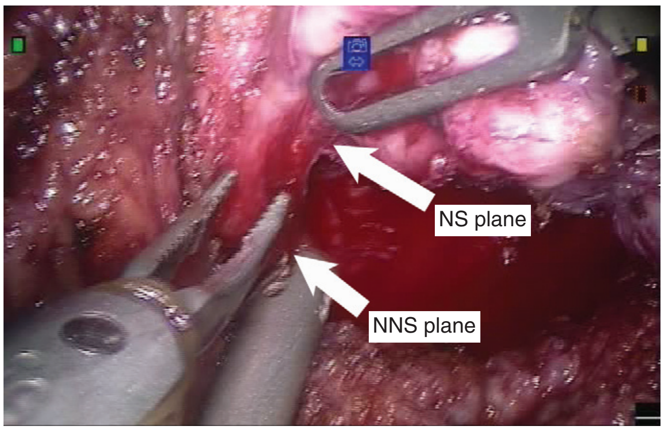
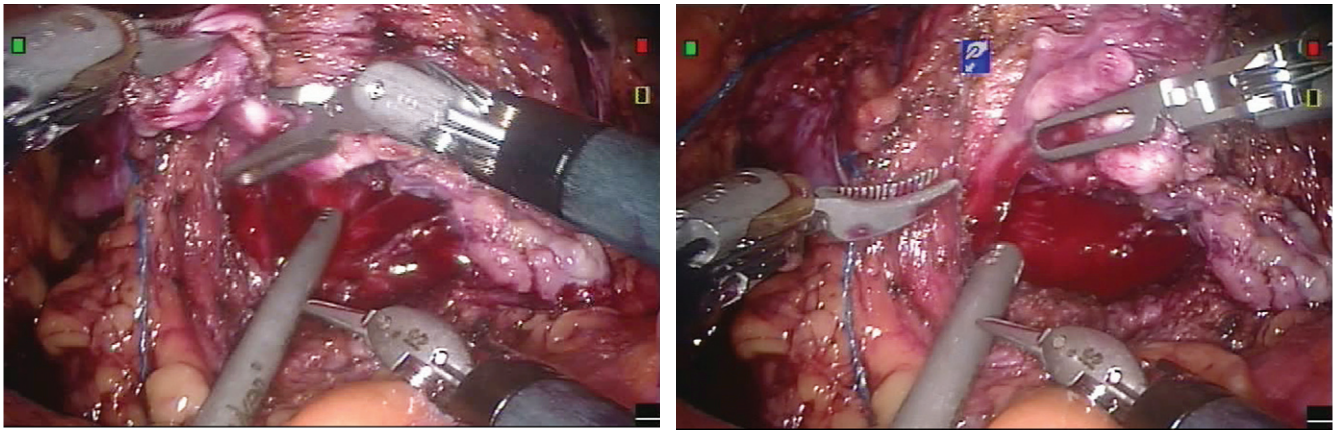


FIGURE 24–11. Once the rectum has been dropped away from the prostate, the neurovascular bundle can be either spared or resected. At this point use of vascular bulldogs has been described to prevent bleeding and possibly promote early return of erectile function. NS, nerve-sparing; NNS, non–nerve-sparing.

or the assistant grasps the most proximal portion of the base of the ipsilateral seminal vesicle and lifts it upward and to the contralateral side to facilitate dissection of a particular pedicle (Fig. 24–12). Keep in mind that to completely preserve the neurovascular bundles, the fascial compartment that encases them must be entered. The location of this bundle can be difficult to see initially; therefore, proceed carefully with the dissection. If there remains any uncertainty posteriorly, move the dissection anteriorly; the lateral prostatic fascia can be entered anteriorly toward the apex of the prostate to establish the proper plane similar to that of many open techniques. This dissection can be continued toward the base of the prostate until it nears the previous posterior dissection point. Once the medial and lateral dissections have been performed as described, divide the pedicle along the capsule of the prostate from base to apex. Careful and sometimes tedious dissection of the pedicle is performed at this point because the prostatic capsule is usually difficult to see in this location. However, once the bulk of the pedicle has been divided, the remainder of the posterolateral



A B

FIGURE 24–12. *A,* The seminal vesicles are useful handles for retraction. *B,* Grasping these structures at their insertion into the prostate helps to prevent inadvertent tearing.

plane opens up very easily and the remaining bundle can be teased away with very little difficulty.

Several different methods have been described to control bleeding around the pedicle, including bipolar cautery and sharp dissection, hemostatic clips, and even placement of bulldog clamps on the pedicles with later oversewing.[5] Intuitively, minimizing energy discharge in the region of the pedicles seems the most prudent; this idea has been supported by experimental work in the canine model.[6] However, clinical outcomes are awaited to support the optimal method for sparing the neurovascular bundle. As the dissection is continued to the apex of the prostate, one must be aware of the proximity of the rectum to the apex of the prostate. Therefore, it is again of great importance to maximize the posterior dissection of the prostate to the apex *before* the lateral dissection is performed, if possible. Once the apex is reached, the anterior urethra is dissected from surrounding tissue. If staples were used to ligate the DVC, a short burst of monopolar cautery expeditiously divides the tissue, allowing the underlying urethra to come into view. The monopolar device is immediately switched out, and cold scissors are used to further dissect the notch of the prostate. The urethra is entered with scissors, and the Foley catheter is withdrawn until it is just visible in the stump of the urethra. The fourth arm is then used to gradually rock the prostate back and forth to provide exposure for division of the posterior urethra and remaining rectourethral attachments. Once freed, the prostate is then entrapped in an entrapment sac and placed in the upper abdomen until the anastomosis is complete.

Urethrovesical Anastomosis

For the anastomosis, I prefer to use the Van Velthoven stitch.[7] This running, double-armed suture has many benefits, including minimizing knot-tying and providing a water-tight anastomosis. The suture consists of 3-0 monocryl sutures tied at the loose ends with a length of 6 to 7 inches for each arm. The needles can be a UR-6, RB-1 but I prefer an SH needle. Once the holding knot is tied, a very small piece of vas is placed as a pledget to bolster the posterior bladder neck. Alternatively, Lapra-Ty can be used (Ethicon Endo-Surgery, Cincinnati, OH).

Start the suture by placing both arms of the suture outside-in at the 6-o'clock position. As a routine, I change the camera back to the 0-degree lens at this point to provide a better view of the urethra. Place the sutures on the urethra inside-out at the 6-o'clock position. Use the right arm of the suture to go outside-in on the bladder, inside on the urethra, outside on the bladder so that the suture exits at about 3 o'clock on the bladder neck. Then slowly but firmly pull the sutures upward so that the bladder neck can be brought into close apposition to the urethra. At this point the vas bolster helps to prevent the knot from "sawing" across the posterior bladder neck. Use the fourth arm to hold the 3-o'clock suture taut, thus anchoring the bladder neck to the urethra. Suture the left-hand suture in the same manner until it exits inside-out on the urethra at the 11-o'clock position. Then lock this suture in the fourth arm and sew the right hand suture to the 1-o'clock position inside-out on the urethra. Pass the transition suture at 12 o'clock outside-in on the urethra and pass it inside-out on the bladder neck. Pass the catheter into the bladder. Tie the suture across the anastomosis. Irrigate with 120 mL of saline via the Foley catheter to test for watertightness. If there is no leak or a small leak, do not place a drain. If a drain is left, it could easily be left through the lateral robot port site.

Exiting

Place the specimen retrieval bag string totally into the abdomen under direct vision. Then remove the camera from the port and place the bag into the lateral 12-mm port site. Place a laparoscopic needle driver into the camera port site, and remove the bag drawstring from the abdomen. Clamp the string with a hemostat. Undock the robot. Remove the trocars under direct vision to check for any bleeding. Remove the specimen by extending the incision of the camera port site to about 4 cm. Open the fascia with cautery until the specimen can be retrieved. Close the port sites with a subcuticular stitch of 3-0 or 4-0 Vicryl, and close the skin with a skin

adhesive (Dermabond, Ethicon, Somerville, NJ) or stitches and Steristrips.

POSTOPERATIVE MANAGEMENT

Remove the orogastric tube in the operating suite. Patients are prescribed ketorolac and morphine as needed for pain. Patients are encouraged to ambulate as soon as possible, usually within 6 hours of returning to their hospital room. A clear liquid diet is instituted that is advanced to a regular diet by the patient's next meal. Discharge is planned for the morning of postoperative day 1. Patients are seen back in 1 week for catheter removal.

COMPLICATIONS

All complications related to laparoscopic surgery readily apply to robotic prostatectomy. Intraoperative complications include bleeding, injury to adjacent organs, and conversion to open surgery. Rectal injury is an ever-present danger, especially in patients with a history of preoperative androgen ablation. In cases of small rectal tears, consideration can be given to primary closure in two layers with interrupted permanent sutures in patients who have been given a preoperative bowel preparation. Copious irrigation of the pelvis and broad-spectrum intravenous antibiotics should be instituted. Large injuries may be handled by conversion to an open procedure with primary rectal repair and consideration of a diverting ileostomy. Postoperative hematuria may be troublesome for some patients. Instruct patients to seek immediate attention for problems involving catheter obstruction related to clot retention. Late complications such as incontinence and impotence are beyond the scope of this chapter but are explained in detail in other sources.

Tips and Tricks

- Meticulous port site selection is the key for allowing adequate working space between the robotic arms. This enables maximum range of motion of the arms, thereby maximizing mobility.
- Clean away the superficial fat over the surface of the prostatovesical junction as completely as possible to enable visualization of the junction.
- The fourth arm provides excellent steady retraction of the vasa, seminal vesicles, and prostate, thereby enabling rapid anterior dissection of the seminal vesicles and precise dissection of the neurovascular bundles. Make every effort to maximize use of the fourth arm.
- Small, frequent camera movements are essential for precise dissection and decreasing operating room times.

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CHAPTER 25

Laparoscopic Radical Cystectomy and Urinary Diversion

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Christian P. Pavlovich

Radical cystectomy with urinary diversion remains the preferred treatment for localized, invasive bladder carcinoma.[1] Beginning in the early 1990s, several urologists investigated the use of laparoscopy as an access technique to perform both extirpative and reconstructive procedures, including radical cystectomy. With improvements in instrumentation and laparoscopic training, more urologists are performing laparoscopic radical cystectomy (LRC); however, it remains an extremely challenging procedure even when performed by experienced laparoscopic surgeons.

Laparoscopic cystectomy was first performed in 1992 by Parra and colleagues for a 27-year-old paraplegic with pyocystis.[2] The first reported LRC for cancer was performed in 1993.[3] Since then there have been numerous descriptions of LRC technique, most of which describe relatively minor variations in the extirpative component of the case.[4–9] The majority of reported cases have involved male patients, although LRC has been performed on female patients. Moinzadeh and colleagues[10] reported their experience in 11 female patients and described the use of a vaginal and uterine manipulator to facilitate the procedure. They were able to successfully perform both anterior exenteration (7 patients) and female organ–sparing cystectomy (4 patients).

The urinary diversion is performed following the cystectomy and can be fashioned either through an open incision, purely laparoscopically, or through a combination of both techniques. As for open surgery, many variations of urinary diversion have been described, including cutaneous ureterostomies, ileal conduit, continent cutaneous reservoir, orthotopic neobladder, and rectosigmoid pouch with ureterosigmoidostomies.

The original reports of laparoscopic-assisted ileal conduits described the extracorporeal creation of the ureteroileal anastomosis through either a small flank or midline incision.[11] More recently, complete intracorporeal creation of the ileal reanastomosis and ureteroileal anastomoses has been described. Gill and colleagues[12] reported the first completely intracorporeal radical cystectomy and urinary diversion by ileal conduit. Two men underwent the procedure for muscle invasive bladder cancer. Operating times were 11.5 and 10 hours, and there were no complications.

Laparoscopic or open rectosigmoid pouch has also been performed after LRC.[5,9] This allows the patient a continent reservoir and avoids an ileal resection and anastomosis but confers with it the concern for later malignancy at the ureterosigmoid junctions, as well as the problems associated with frequent watery stools.

For many urologists, orthotopic ileal neobladder has become the preferred method of diversion in appropriate candidates. Laparoscopic urologists have therefore had a natural progression toward attempting to incorporate this method of diversion into their armamentarium. Most groups to date have completed the neobladder through a midline or Pfannenstiel incision following laparoscopic cystectomy.[4,6] Basillote and associates[4] compared LRC with an ileal neobladder created through a 15-cm Pfannenstiel incision to patients undergoing traditional open radical cystectomy with neobladder creation. They found there was less postoperative pain and a shorter hospitalization in the LRC patients. Others have performed part[13] or all[7] of the neobladder intracorporeally. Gill and colleagues[14] investigated a completely intracorporeal ileal neobladder in a porcine model. They fashioned a neobladder with a Studer limb in 12 animals with generally good success. The same group has reported on their human experience with complete intracorporeal orthotopic ileal neobladder in two patients. The operative time was 8.5 and 10.5 hours. Both patients had daytime dryness, and postoperative radiography revealed unobstructed systems.[7]

In conclusion, many institutions have successfully performed LRC, although oncologic follow-up is relatively short and published patient numbers are few. Many variations of urinary diversion have been described; as groups increase their experience, more purely laparoscopic techniques will be used successfully.

INDICATIONS AND CONTRAINDICATIONS

Indications for LRC mirror those for open radical cystectomy: tumor invading the muscularis propria, high-grade or invasive tumors associated with carcinoma in situ, carcinoma in situ resistant to intravesical therapies, or recurrent, bulky, or symptomatic superficial tumors.[1] Cystectomy has also been performed for noncancerous causes such as chronic pyocystis, intractable pelvic/bladder pain, interstitial cystitis, or hemorrhagic cystitis.

Absolute contraindications to LRC include severe coagulopathy and active intra-abdominal or urinary infection. Relative contraindications include those common to other laparoscopic procedures, namely, severe cardiopulmonary disease, chronic obstructive pulmonary disease (COPD), obesity, and multiple previous intra-abdominal procedures. Clinicians early in their learning curve must be extremely selective and avoid patients with any of the above issues. With more experience, laparoscopic surgeons can perform this procedure with fewer restrictions on patient selection. Currently, even the most experienced laparoscopists require 7 hours or longer to perform complete LRC with urinary diversion. Moreover, for much of this time the patient remains in steep Trendelenburg position. The prolonged pneumoperitoneum is of concern for patients with

COPD because they have decreased ability to release CO_2, resulting in hypercapnea, hypercarbia, acidosis, and the potential for cardiac arrhythmias. Furthermore, prolonged Trendelenburg position negatively affects the anesthesiologist's ability to ventilate the patient due to increased diaphragmatic pressure on the pleural cavity.

In regard to obese patients, simply establishing laparoscopic access can be technically challenging. Moreover, long instruments may be required to safely reach the pelvis. Creation of an ileal loop diversion in overweight patients can be problematic due to the relatively short bowel mesentery compared with a thick abdominal wall. Large amounts of intra-abdominal fat may also make dissection and exposure more difficult. For these reasons, extensive experience with laparoscopy and open surgery in obese patients is recommended before this undertaking.

Previous intra-abdominal procedures can create bowel adhesions and increase the risk of bowel injury. Use extreme care when inserting trocars to avoid inadvertent bowel injury. With experience, bowel adhesions can be mobilized readily using sharp dissection without cautery, usually allowing a straightforward procedure.

In summary, until the surgeon becomes very confident with this procedure, patients should be thin, have had no previous intra-abdominal surgery, and not have obvious bulky disease. Patients with one or more contraindications may nevertheless be considered possible candidates for LRC followed by open creation of urinary diversion.

PATIENT PREOPERATIVE EVALUATION AND PREPARATION

Before radical cystectomy, patients undergo evaluation to rule out metastatic disease. Axial imaging by computed tomography (CT) or magnetic resonance imaging (MRI) with contrast is recommended to assess for tumor bulk, local extension, regional and distant lymphadenopathy, and distant metastasis. Chest, abdominal, and pelvic imaging are recommended, although for lower-stage disease, a chest radiograph rather than CT or MRI should suffice. Bone scans have not proved necessary and are reserved for patients with bony symptoms or significantly elevated alkaline phosphatase. A bimanual examination is also recommended to better estimate residual tumor bulk following transurethral resection because large tumor bulk or questionably fixed disease makes laparoscopic cystectomy significantly more challenging and indicates a poorer prognosis.

Before laparoscopic cystectomy, adequate mechanical and antibiotic bowel preparation are recommended. Marking for an ileal conduit by an enterostomal therapist is also recommended regardless of the diversion entertained in case of inability to perform continent diversion for whatever reason. Prophylactic anticoagulation is strongly considered. General anesthesia with or without regional anesthesia for added intraoperative and postoperative pain management is recommended.

OPERATING ROOM CONFIGURATION AND PATIENT POSITIONING

The room is set-up so that both surgeon and assistants can see the operative field easily (Fig. 25–1). Because these are lengthy procedures, the monitors, one on each side, are set up at the proper height to minimize neck strain and also angled so that personnel will not have to crane their necks to see them. A right-handed surgeon typically stands on the left side with an assistant on the right side. The scrub nurse is also on the right closer to the patient's feet. A monitor is between the first assistant and the scrub nurse (for the surgeon) and one is on the other side for the assistant and nurse. An accessory monitor for others watching the procedure away from the operative field can be set up as well. All instrument trays are kept at the foot of the bed and to the right of the scrub nurse.

Place the patient supine with arms adducted, with all pressure points well padded, on an electric operative table. The frog-leg position is adequate for male patients unless total urethrectomy is planned, in which case a low modified lithotomy with stirrups is used. Place female patients in low modified lithotomy as well, with Yellowfins or comparable stirrups that allow for easy access to both perineum and abdomen. If used, the Automated Endoscopic System for Optimal Positioning (AESOP) robotic camera-holder (Intuitive Surgical, Sunnyvale, CA) is fastened to the operating room table on the right side just lateral to the right shoulder. Then secure the patient to the operative table with heavy, wide tape strips (over towels) placed over legs, thighs, and upper chest, such that there is no patient movement during Trendelenburg or airplaning of the table intraoperatively. Once the patient is prepped and draped, insert a sterile Foley catheter.

TROCAR PLACEMENT

A five-port approach is used (Fig. 25–2). Insufflate the abdomen via the superior aspect of the umbilicus with a Veress needle to establish pneumoperitoneum. Once 15-mm pressure is reached, make a 12-mm incision just above the umbilicus (to stay above the urachus), and place a 10/12-mm trocar through it using a Visiport (U.S. Surgical, Norwalk, CT). Subsequently use direct visualization to place the other ports. Two 10/12-mm ports are a necessary minimum: the initial one for the camera at the umbilicus, and one for the main working port lateral to the right rectus muscle at the level of the umbilicus. The 10/12-mm ports are required for easy use of the endo-GIA stapler, and most surgeons prefer having another 12-mm port (rather than a 5-mm port) on the left side as well, for the flexibility of using of an endo-GIA or 10-mm clip applier on that side. Two more ports are routinely placed: a 5-mm port superomedial to the anterior superior iliac spine on the right (for the assistant), and another in mirror-image location on the left side (for retraction of structures by the surgeon and/or second assistant if available), taking care to avoid the epigastric vessels (Fig. 25–3). Retraction through such a port by the surgeon can be done with a locking grasper that is then fixed to the drapes by pulling the drape through the instrument handle and clamping the drape and instrument in position with a Kelly clamp or similar instrument.

PROCEDURE

Pelvic Lymphadenectomy

Place the patient in modest Trendelenburg slightly airplaned toward the surgeon. For most cases, use the right and left ports

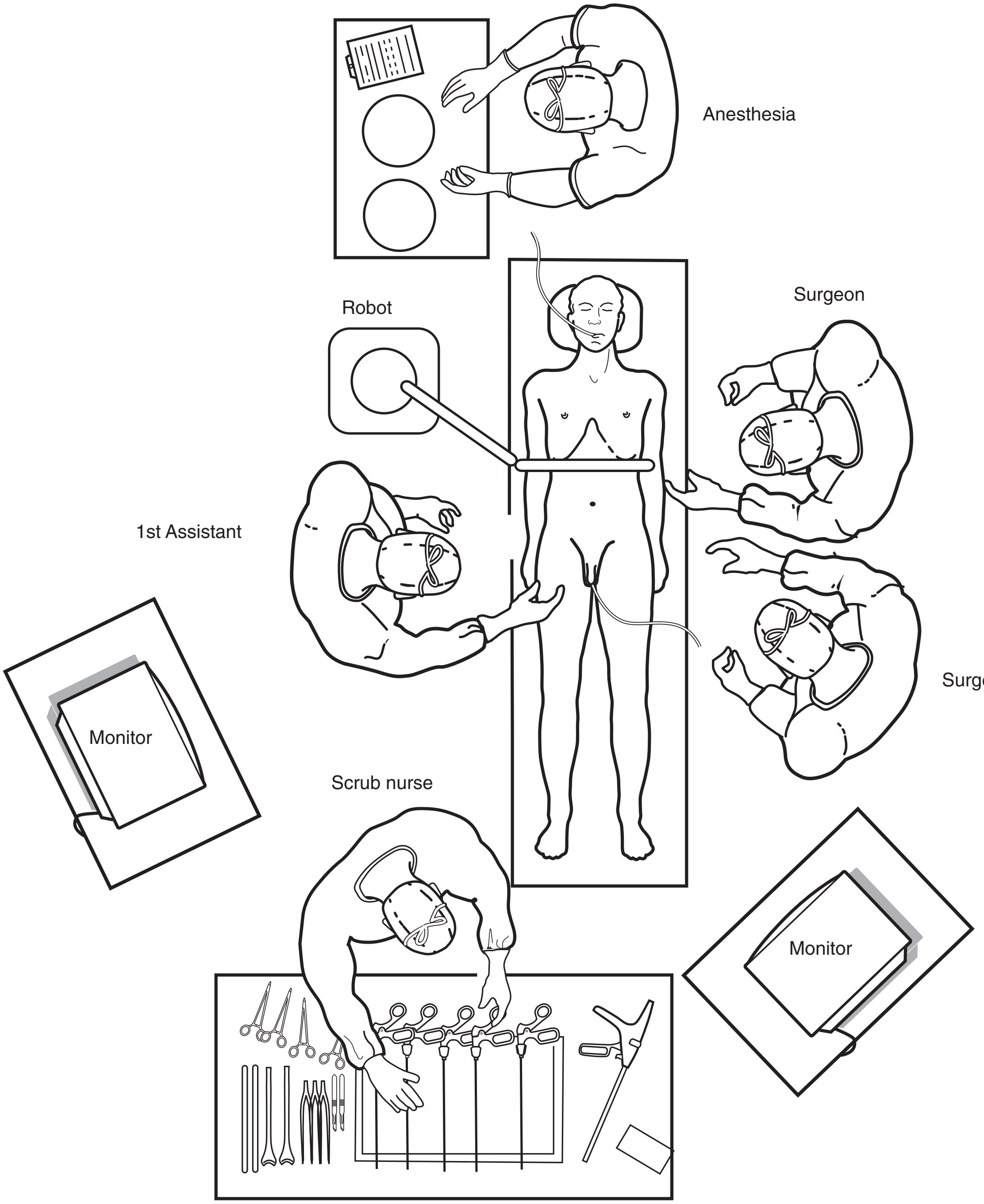


FIGURE 25–1. Operating room setup. The surgeon is typically on the left side, and the first assistant and camera-holding robot are on the right. Each gets a dedicated monitor, unless a large screen is available at the foot of the bed.

that most closely flank the umbilicus. With an alligator grasper in the left hand and a working tool in the right hand (our preference is the Harmonic ACE ultrasonic instrument [Ethicon Endo-Surgery, Cincinnati, OH]), inspect the abdomen for carcinomatosis. If the decision is made to proceed, incise the parietal peritoneum over the vasa deferentia as they cross over the median umbilical ligament (Fig. 25–4).

In men, clip and cut the vasa because they are the median umbilical ligaments, allowing optimal exposure of the pelvic lymph node beds and the posterolateral bladder pedicles (Fig. 25–5). Perform bilateral obturator and iliac lymphadenectomies, staying medial to the genitofemoral nerves and inferior to the bifurcation of the iliac arteries, unless a more extended lymphadenectomy is chosen. Extract these lymph node specimens in discrete packets through the 10/12-mm working ports. Use the distal ends of the vasa as guides to identify the tips of the seminal vesicles, which are identified in order to allow for nerve-sparing cystectomy (Fig. 25–6). Finally, join the parietal peritoneum incisions on either side in the midline posterior to the bladder (see Fig. 25–4).

In women, identify the ureters as they cross over the iliac arteries, and dissect the pelvic lymph node packets identically.

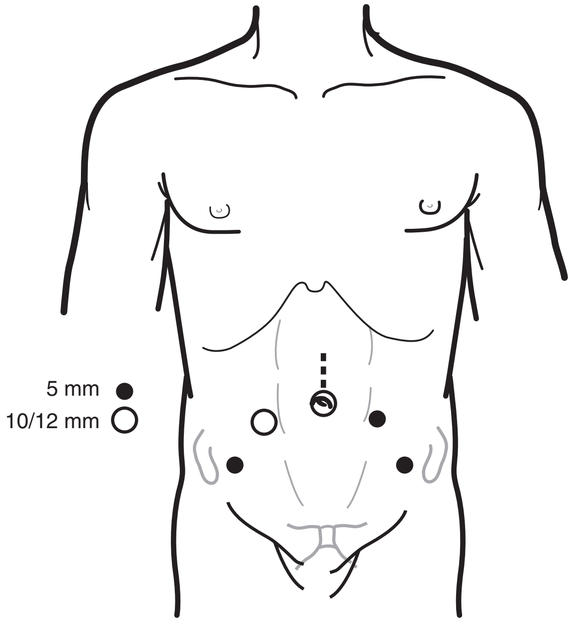


FIGURE 25–2. Port placement. At least two 10/12-mm ports should be used, one for a camera and one for needle, Endo-GIA stapler, and other large-bore instrument insertion. The other three ports can be 5-mm ports.

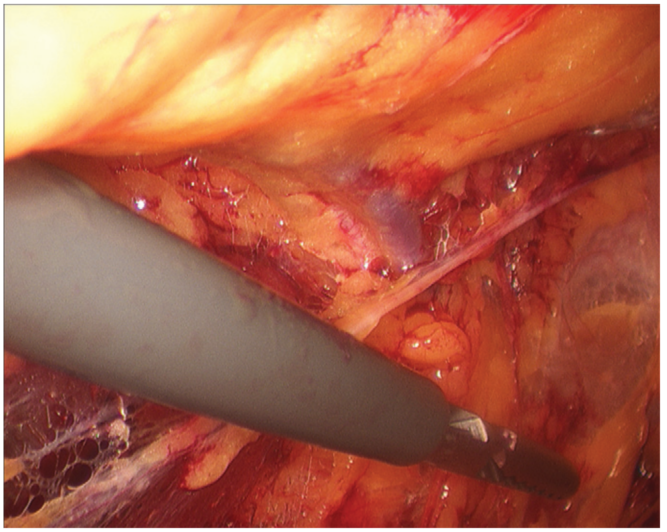


FIGURE 25–3. Ports may require being placed close to the epigastric vessels, which fortunately can be well visualized in some patients and carefully avoided.

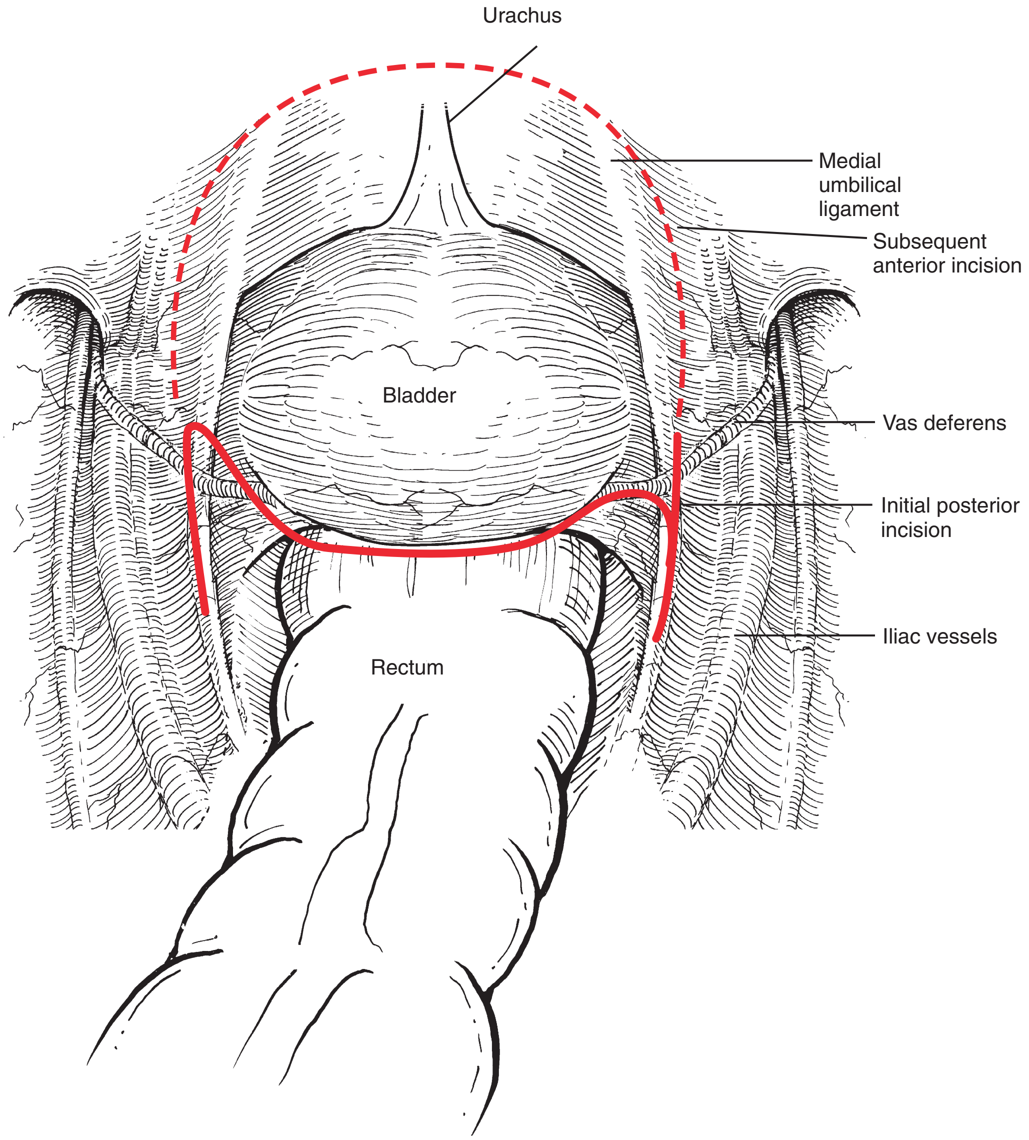
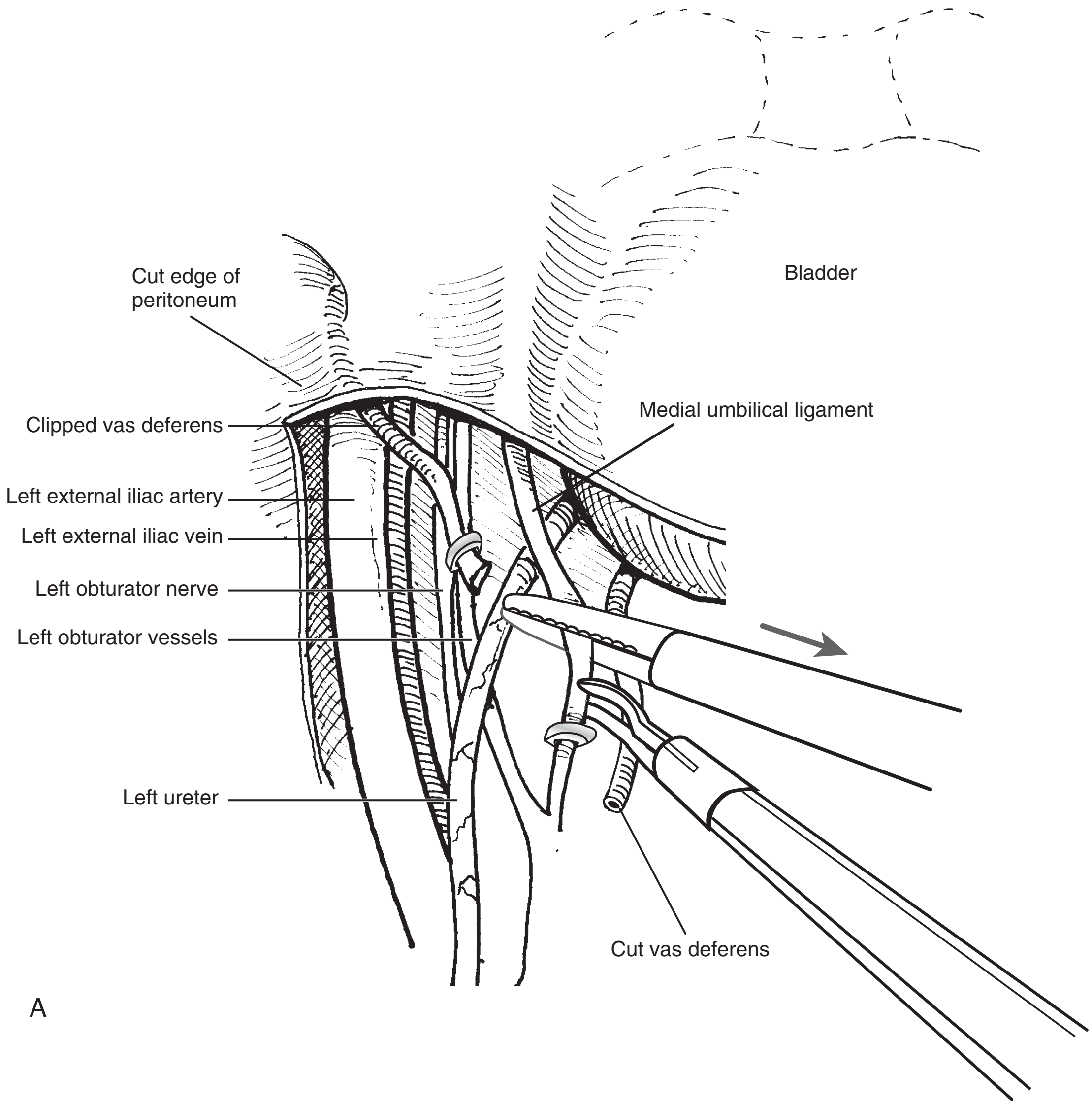


FIGURE 25–4. Peritoneal incision lines. These can be made with a cautery hook or with ultrasonic shears. They are necessary to find the vasa deferentia, dissect posteriorly, and then dissect anteriorly.



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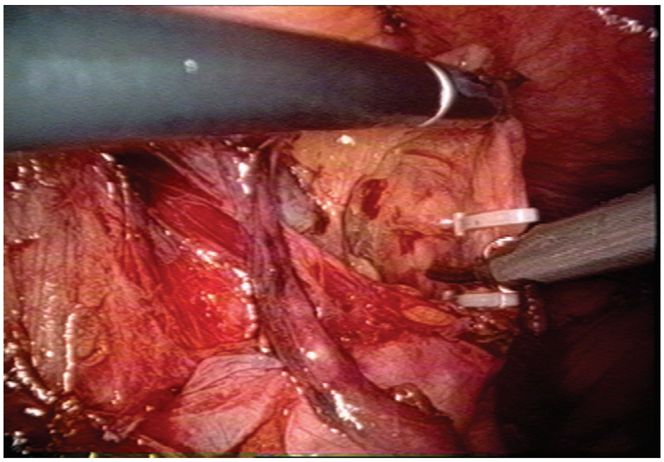
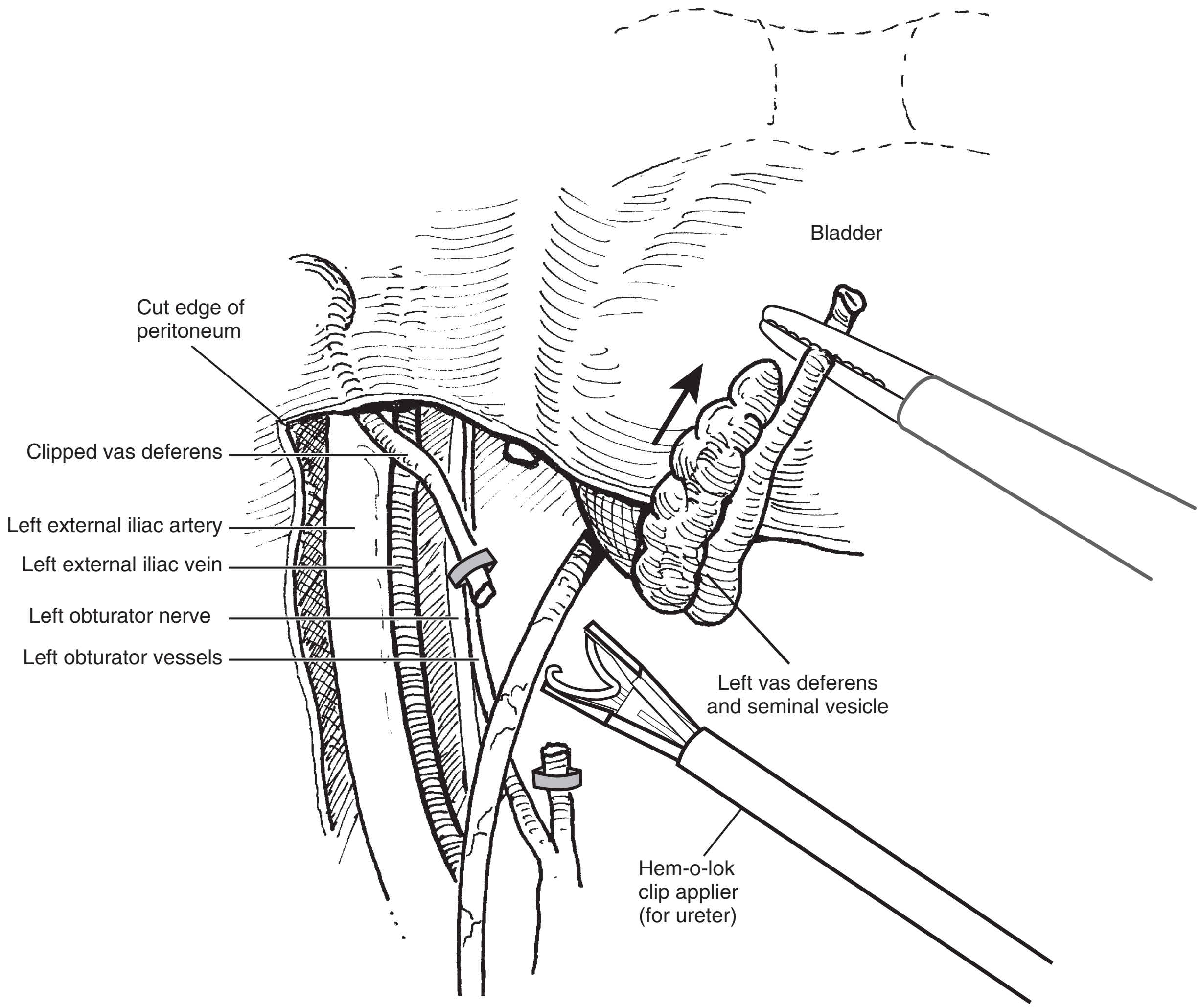


B

FIGURE 25–5. *A,* Exposing left posterior bladder. An alligator forceps is being used to retract the left medial umbilical ligament, which has been clipped and is being cut. This maneuver exposes the external iliac vein to help initiate pelvic lymphadenectomy. *B,* To initiate the left pelvic lymphadenectomy, the left medial umbilical ligament is being retracted medially to expose the left external iliac vein. The left vas deferens has already been transected, and the medial umbilical ligament is now being clipped and cut.



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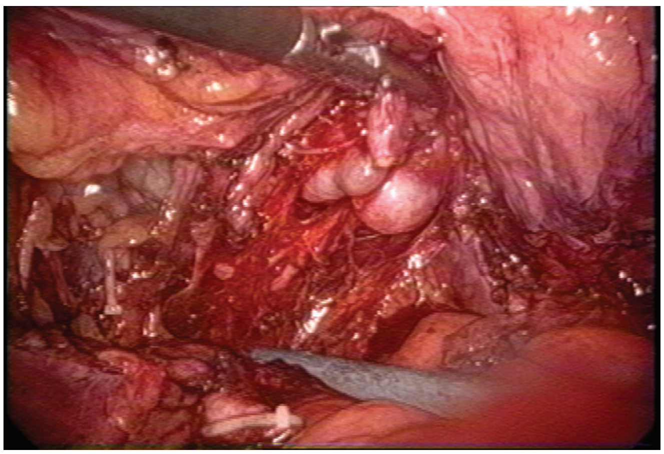


B

FIGURE 25–6. *A,* The ureter's course into the bladder can be followed once the vas has been cut and its distal stump and the seminal vesicle are retracted superomedially. *B,* The distal left vas deferens (specimen side) is being retracted superomedially to identify the left seminal vesicle for nerve-sparing dissection.

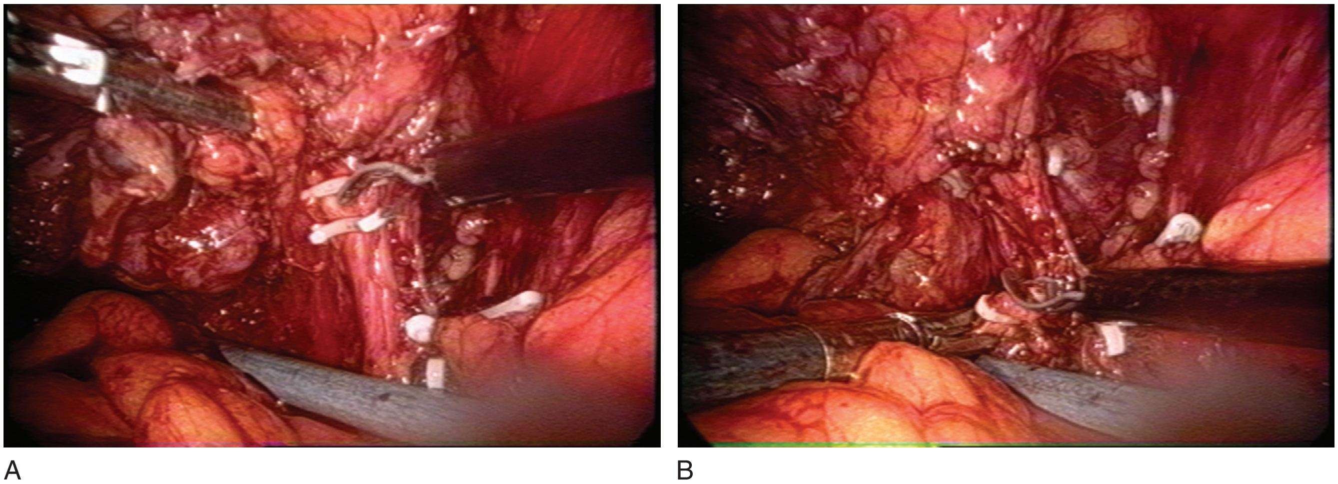


FIGURE 25–7. *A,* The right ureter is being clipped and cut. The distal cut end of the right vas deferens is being held for medial retraction, exposing the right seminal vesicle tip and the right ureter. *B,* The proximal end of the right ureter is being held up and a distal margin is being taken with scissors for frozen section analysis.

Taking the medial umbilical ligaments can also facilitate the lymph node dissection.

Ureters

Identify the ureters as they cross over the iliac arteries and dive inferiorly into the pelvis. More distally, they lie just lateral to the seminal vesicles in men (Figs. 25–6*A* and 25–7*A*). Once identified and followed toward the bladder in patients of either gender, take the ureters about 2 cm from their vesical insertion (see Fig. 25–7*A*), clip them, and send a frozen section of each distal ureter for pathologic analysis (see Fig. 25–7*B*).

Posterior Dissection

In men, incise Denonvillier's fascia in the posterior midline just inferior to the prostatic midline where the seminal vesicles insert. It may help to retract the sigmoid posterosuperiorly and the bladder superiorly. Identify the plane between the rectum and posterior prostate and develop it bluntly. Lateral to it, the vascular pedicles to the bladder come into view. Retracting a seminal vesicle tip medially and superiorly and working laterally to this, take one and then the other pedicle with roticulating endo-GIA staplers (2- to 2.5-mm clips, 4.5-cm length) (Fig. 25–8). Typically, two in-line firings are needed on each side (Fig. 25–9).

In women, retract the uterus anteriorly and the sigmoid posterosuperiorly as necessary, and use an endo-GIA stapler to transect the infundibulosuspensory ligaments. Taking these ligaments with their associated ovarian vasculature allows anterior retraction of the adnexal structures and exposure of the peritoneum overlying the posterior vaginal fornix. This can be identified by a sponge stick in the vagina or, as recently demonstrated by Moinzadeh and colleagues,[10] using a Koh cervical cup and Rumi manipulator (Cooper Surgical, Shelton, CT). Gently score the parietal peritoneum here with electrocautery, and turn attention anterolaterally at this point.

Anterior Dissection

In men, the final firings of the endo-GIA lead one to the prostatic pedicles. At this point, proceed to the anterior dissection, which is accomplished via a parietal peritoneal inverted-U–shaped incision incorporating the urachus and bladder that connects with the peritoneotomy made for the posterior dissection (see Fig. 25–4). This can be facilitated by instilling 120 mL of saline in the bladder temporarily. Then drop the bladder, define the space of Retzius, and expose the puboprostatic ligaments. Incise the endopelvic fasciae and puboprostatic ligaments, and place and tie a dorsal vein stitch (2-0 Vicryl, GS-21 needle) (Fig. 25–10). Cut the dorsal vein using an electrocautery hook, ultrasonic shears, or an endo-GIA stapler, and expose the urethra. At this point, cut the urethra with scissors, leaving just enough of a stump to clip with a 10-mm Hem-o-lok (Weck Closure Systems, Research Triangle Park, NC) in order to prevent urine spillage (Fig. 25–11). Typically, send a distal margin for frozen section, and remove the catheter. Sharply incise the posterior striated sphincter, and then perform retrograde dissection of the prostatic pedicles, with nerve-sparing possible as clinically indicated (Fig. 25–12).

In women, drop the bladder in similar fashion, until the bladder pedicles come into view. Remember to empty the bladder of any instilled saline, then grasp detrusor muscle near the clipped distal ureteral stumps and retract superomedially. As the assistant provides inferolateral countertraction on the pelvic floor, the pedicles come into view. Again, two firings of a roticulating endo-GIA stapler (2- to 2.5-mm clips, 4.5-cm length) are usually adequate for each pedicle. At this point, proceed anteriorly to the midline, retracting both uterus and bladder inferiorly and exposing the endopelvic fascia and dorsal vein. Work here just as in men, incising the fasciae and controlling the dorsal vein. Then move posteriorly again and cut through the posterior fornix in the midline onto a sponge stick or onto the Koh cervical ring. Extend this incision into the vagina on both sides distally to the vaginal outlet, typically excising the anterior third of the vagina as a strip en bloc with the posterior bladder. One way to prevent loss of pneumoperi-

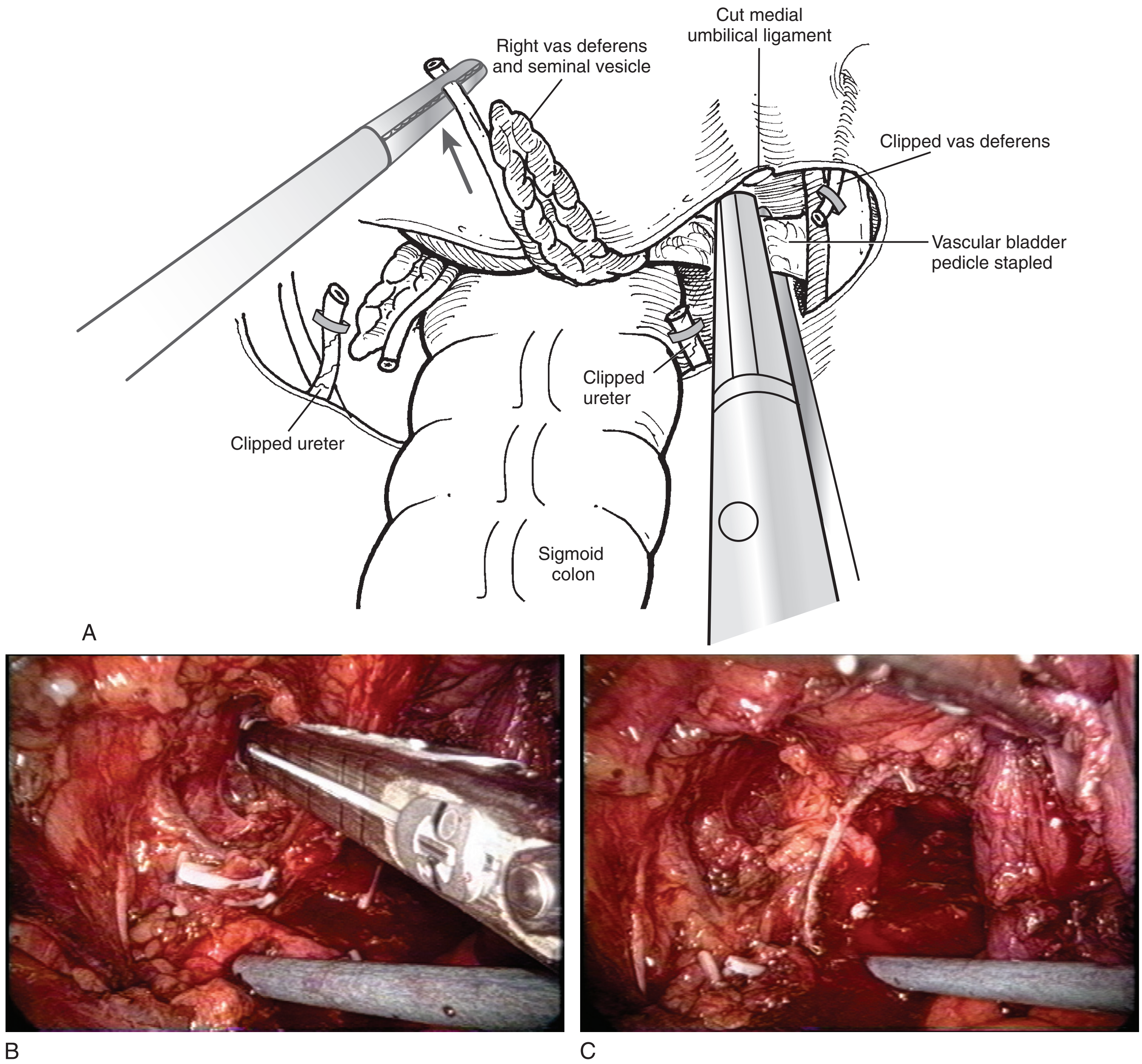


FIGURE 25–8. *A,* Taking right bladder pedicle. Once the ureters have been transected, the vascular bladder pedicles can be taken with roticulating Endo-GIA stapling devices as the vas/seminal vesicle complexes are retracted superomedially. *B,* The left pedicle is being taken with a roticulating Endo-GIA stapling device (2.5-mm clips). *C,* The Endo-GIA stapler has been fired once and the first clip line is seen at the left pedicle.

toneum is to occlude the vagina with a wet laparotomy pad placed in a surgical glove, and apply this to the vaginal vault. However, the insufflation balloon that is a part of the Koh colpotomizer system is quite effective for this purpose.

Specimen Extraction

In men, once the retrograde dissection lines meet the endo-GIA pedicle clips, clip and cut final attachments with Hem-o-lok clips, freeing up the specimen. Place the specimen into a 15-mm EndoCatch (U.S. Surgical) impermeable bag and cinch it shut (Fig. 25–13). Specimen extraction is typically done via a lower midline incision, which is then used for extracorporeal creation of the urinary diversion, although specimen extraction can also be performed through an enlarged subsequent ileal conduit stoma site, and even rectum (before rectosigmoid pouch creation). If urethrectomy is indicated, it may proceed once the specimen is extracted.

In women, handle the urethra as in the previous section if orthotopic diversion is planned. Alternately, if total en bloc urethrectomy is planned, do not cut the urethra during the anterior dissection but instead core it out perineally with electrocautery along with the anterior vaginal wall. Once freed up, extract the specimen transvaginally, then perform laparoscopic vaginal reconstruction (usually a running 2-0 Vicryl stitch is

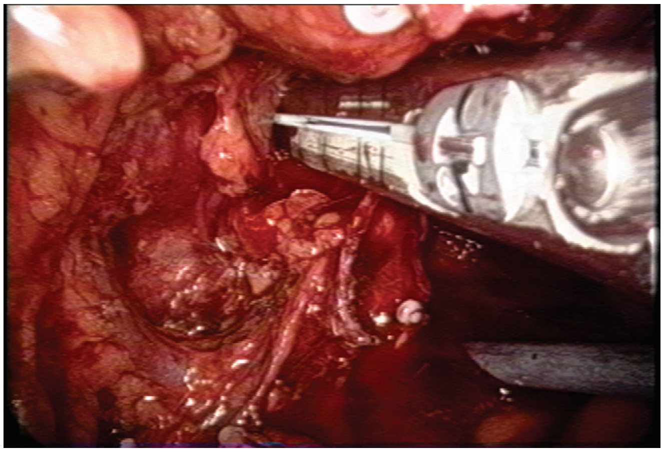
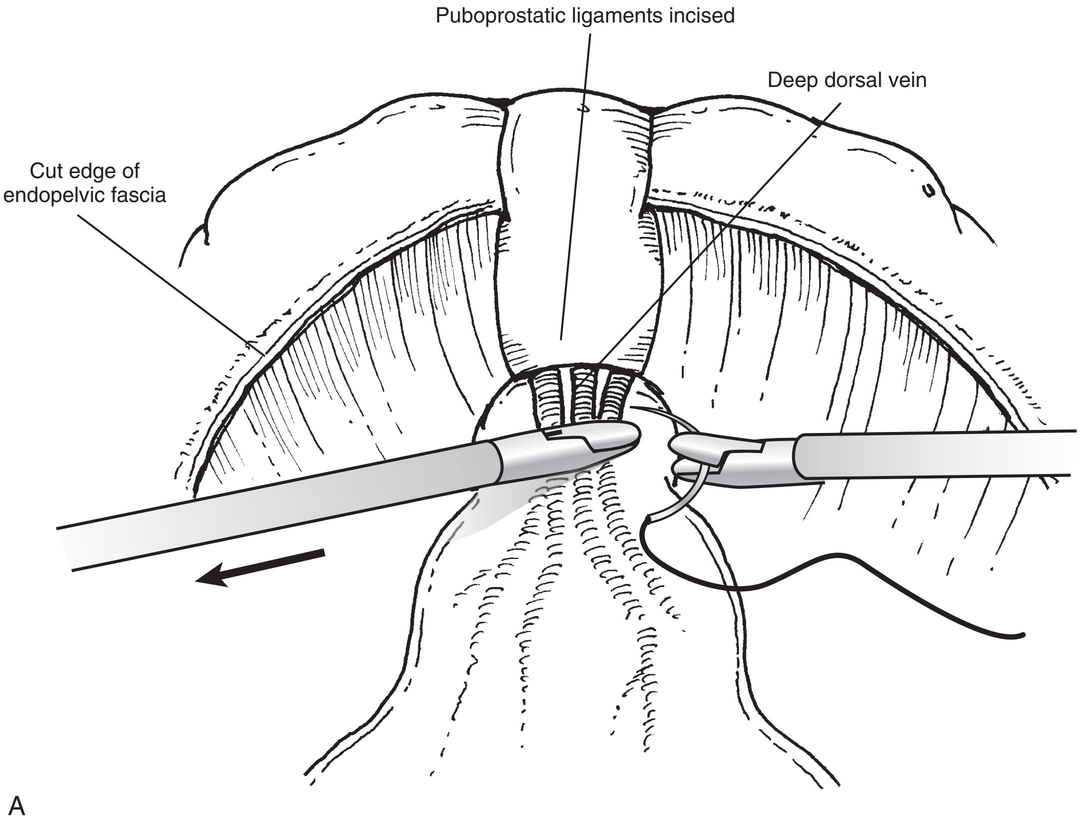


FIGURE 25–9. The roticulating Endo-GIA is being fired a second time, this time more distally and toward the prostatic pedicle, roticulated away from rectum.



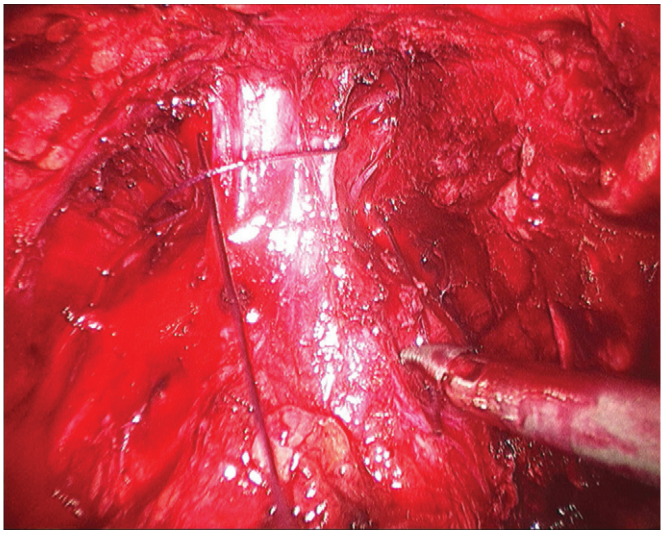
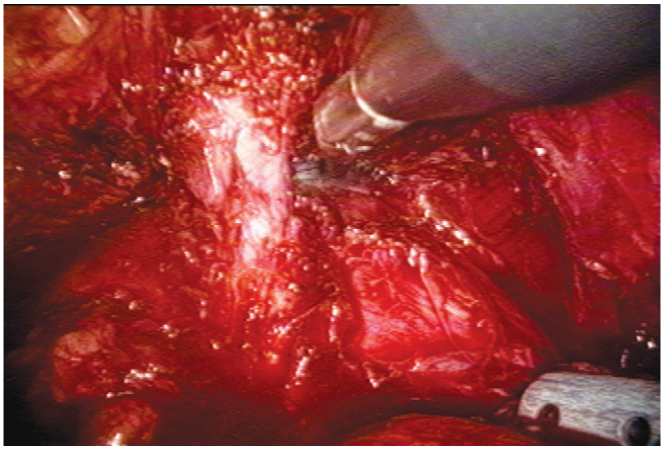


FIGURE 25–10. *A,* Anterior view. The endopelvic fasciae are incised and the puboprostatic ligaments are identified and incised. A dorsal vein stitch is placed and tied by throwing one pass under the dorsal vein complex and one just above it, in horizontal figure-of-eight fashion. This helps lock the suture into place before dorsal vein transection. *B,* Dorsal vein ligation using a 2-0 suture in a figure-of-eight fashion.



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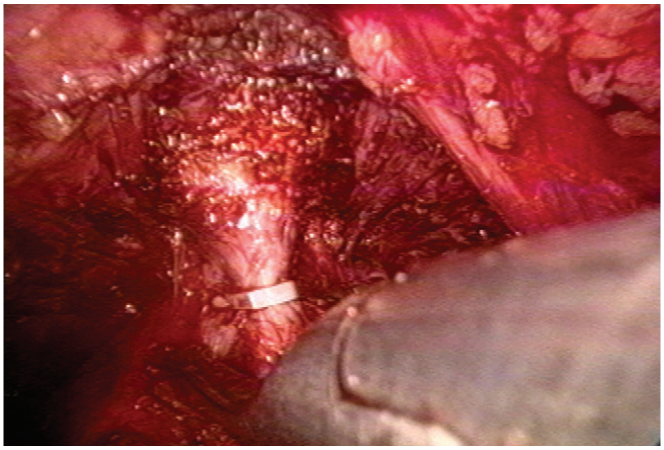

B

FIGURE 25–11. *A,* Sharp right-angle is being used to define the urethra anteriorly. *B,* A large Hem-o-lok clip is being placed on the urethra before cutting it to prevent spillage of urine into the field.

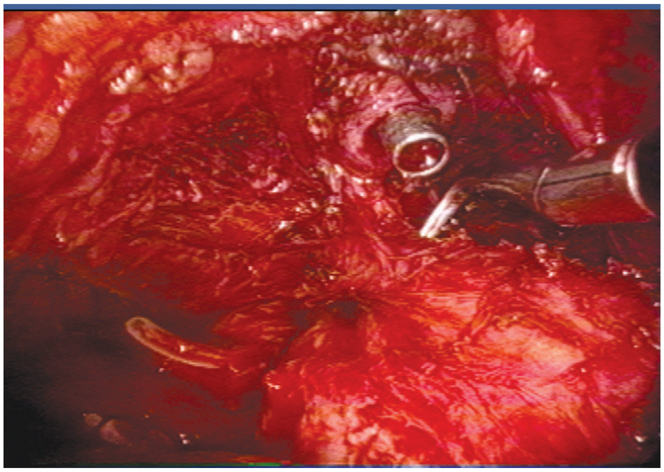

FIGURE 25–12. The urethra cut, attention is made, if clinically indicated, to nerve-sparing at the prostate apex and retrograde (left side in photograph).

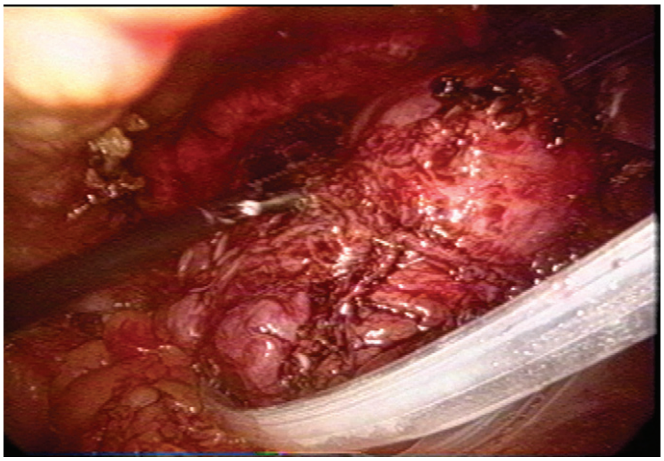

FIGURE 25–13. The radical cystoprostatectomy specimen is placed in a 15-mm EndoCatch bag with grasping forceps.

used to reapproximate the cut anterior vaginal edges, locking every other throw).

Urinary Diversion

The choice of diversion type should not be influenced by the laparoscopic skill of the surgical team. If there is any question regarding laparoscopic suturing ability or experience overall, then perform an extracorporeal urinary diversion or reconstruction. However, because there may be benefits (e.g., blood loss, evaporative loss, technical precision) and little downside to performing the extirpative portion laparoscopically, the reconstructive choice should not in turn influence the choice of open versus laparoscopic cystectomy.

At this time, some experienced laparoscopic teams still favor an extracorporeal reconstruction following laparoscopic cystectomy in the interests of surgical time, familiarity, and documented functional outcomes conferred by open diversions/reconstructions. Although there are many possible diversions, urologists must keep at least two options in their armamentarium—the ileal conduit and the orthotopic neobladder—both intermediate in difficulty but optimal in quality-of-life benefit compared with simpler ureterocutaneous diversions or significantly more complex continent catheterizable pouches.

Ileal Conduit Urinary Diversion

The principles of ureteroileal conduit are the same whether the conduit is performed intracorporeally or extracorporeally. It is helpful to spatulate the ureters and tag them with a stitch. Bring the left ureter under the sigmoid mesentery for right-sided conduits. Select a 15- to 20-cm segment of ileum about 15 cm from the ileocecal valve, tag it with a stitch on either side, and then bring it extracorporeally through the extraction incision. Alternately, identify the appropriate areas intracorporeally. Then divide the ileum proximally and distally at these sites with an endo-GIA stapler. Recontinuity of the bowel can be accomplished isoperistaltically as elegantly demonstrated in the laparoscopic technique of Abrahams and colleagues[15] using 6 to 10 cm of overlapping ileum and one or two firings of an

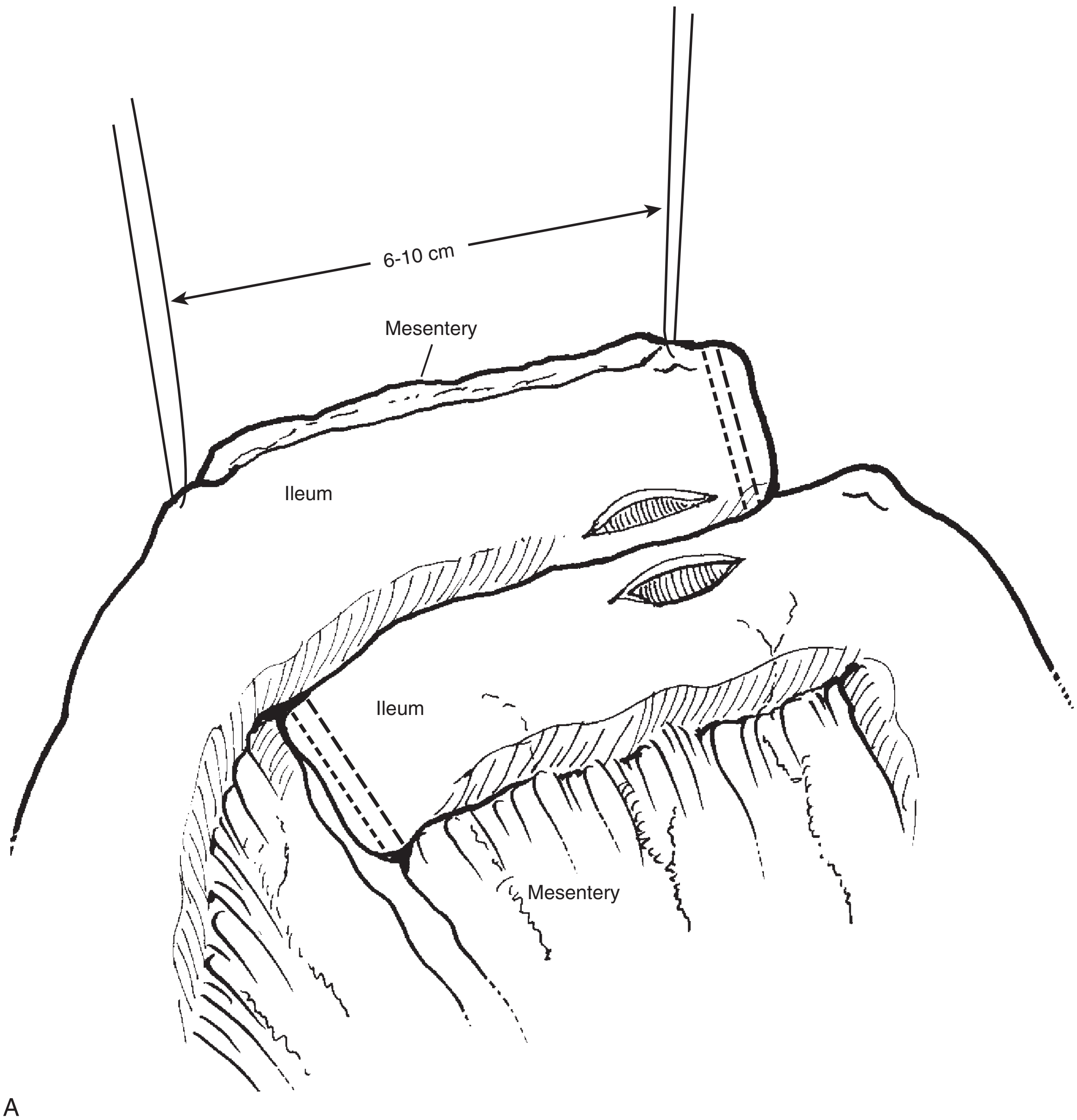

FIGURE 25–14. Laparoscopic bowel reanastomosis. Bowel reanastomosis can be facilitated *(A)* by apposing the bowel segments at their antimesenteric borders, making a small incision in each, and then

endo-GIA stapler (Fig. 25–14). Then close the stapler insertion sites with three to six interrupted silk Lembert sutures in a single layer, and close the mesenteric trap with interrupted silk sutures.

Mature the ileum to the abdomen at the chosen stoma site, and then make the ureteroileal anastomoses. Gill and colleagues[12] described passing a single-J stent into the conduit with a laparoscopic right-angle clamp and using the clamp to define the site for ureteroileal reanastomosis near the conduit butt end. Make a small ileotomy and pass the stent through it and into the proper ureter. Then make an anastomosis over this stent in running fashion while passing the stent up to the renal pelvis. Repeat this for the other ureter. After irrigating the stoma with a bulb syringe to make sure the anastomoses are watertight, place a Jackson-Pratt drain through a 5-mm trocar site, terminating near the conduit butt end. Alternately, make a Wallace ureteroileal anastomosis by cutting off the butt end of the conduit and using that opening to reconnect the spatulated ureters (Fig. 25–15*A, D*). Sew these together first and then bring them to the butt end and connect them there in running fashion.

Studer-Limb Orthotopic Neobladder

Fashion a Studer-limb or Hautmann neobladder in standard extracorporeal manner through the lower midline specimen extraction incision. Then perform the ureteroileal and ileourethral anastomoses laparoscopically following the creation of the neobladder, or make them in open fashion, depending on the level of comfort with free-hand laparoscopic suturing. The

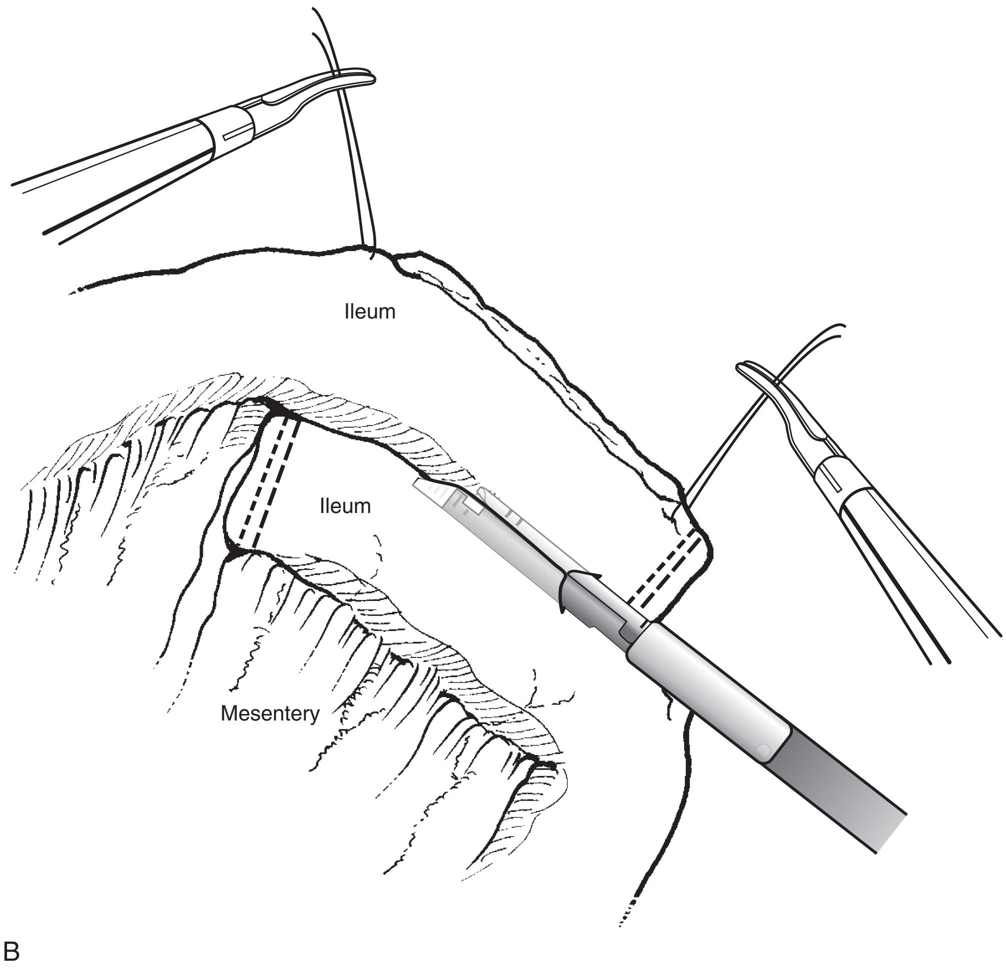

FIGURE 25–14, cont'd. *(B)* by using an Endo-GIA stapling device to re-create a lumen between the two.

completely intracorporeal procedure as described by Gill and associates in 2002[7] mandates making the left lateral port a 10/12-mm port and adding a sixth lower midline port to the standard port configuration demonstrated in Figure 25–2. The camera is moved to the left lateral port during reconstruction, and the surgeon typically works through the lower midline port and the right pararectal port. Then 65 cm of ileum is selected 15 cm from the ileocecal valve and divided with use of an endo-GIA stapler (see Fig. 25–15*B*). Mesentery is taken with vascular endo-GIA loads as appropriate to maintain the vasculature of the isolated segment, and the distal 50 to 55 cm of the bowel segment is detubularized and re-sewn together to form the spherical reservoir (see Fig. 25–15*C*). Gill and associates perform their laparoscopic urethroileal anastomosis at this juncture, a step greatly facilitated by laparoscopic prostatectomy experience.

Subsequently, a Wallace ureterointestinal reanastomosis can be made to the proximal Studer limb after cutting off the staple line (see Fig. 25–15*D*), or two Bricker anastomoses can be made. Single-J stents are used in either case and are passed out alongside the Foley catheter or out via small, separate ileotomies and extracorporeally. A Jackson-Pratt drain is placed via a 5-mm trocar site, and a suprapubic tube is placed (optional).

POSTOPERATIVE MANAGEMENT

Patients are typically transferred to a surgical intensive care unit or step-down unit for the evening immediately following surgery. Postoperative blood work includes serum chemistries and complete blood count. A nasogastric tube may be kept in place until bowel function resumes, usually in 2 to 3 days. If there is no postoperative ileus, diet is slowly advanced over the next 3 days. Patients are ambulated at least four times beginning on postoperative day 1 and then six times per day starting on postoperative day 2. Venous compression stockings and antiembolism boots are applied while in bed for deep venous thrombosis prophylaxis until discharge. Subcutaneous unfractionated heparin can also be used for additional protection against thromboembolic events. Jackson-Pratt drains are left in place until drainage decreases to 100 mL per day or less. If there is a question of urine leak, the drain fluid is sent for creatinine level.

For patients with neobladder creation, the suprapubic and urethral catheters are irrigated every 4 to 6 hours until discharge and then three times per day with sterile saline until clear of mucus. The ureteral stents are removed at day 7, and the urethral catheter is removed at 3 weeks. A cystogram is performed through the suprapubic catheter at 4 weeks to

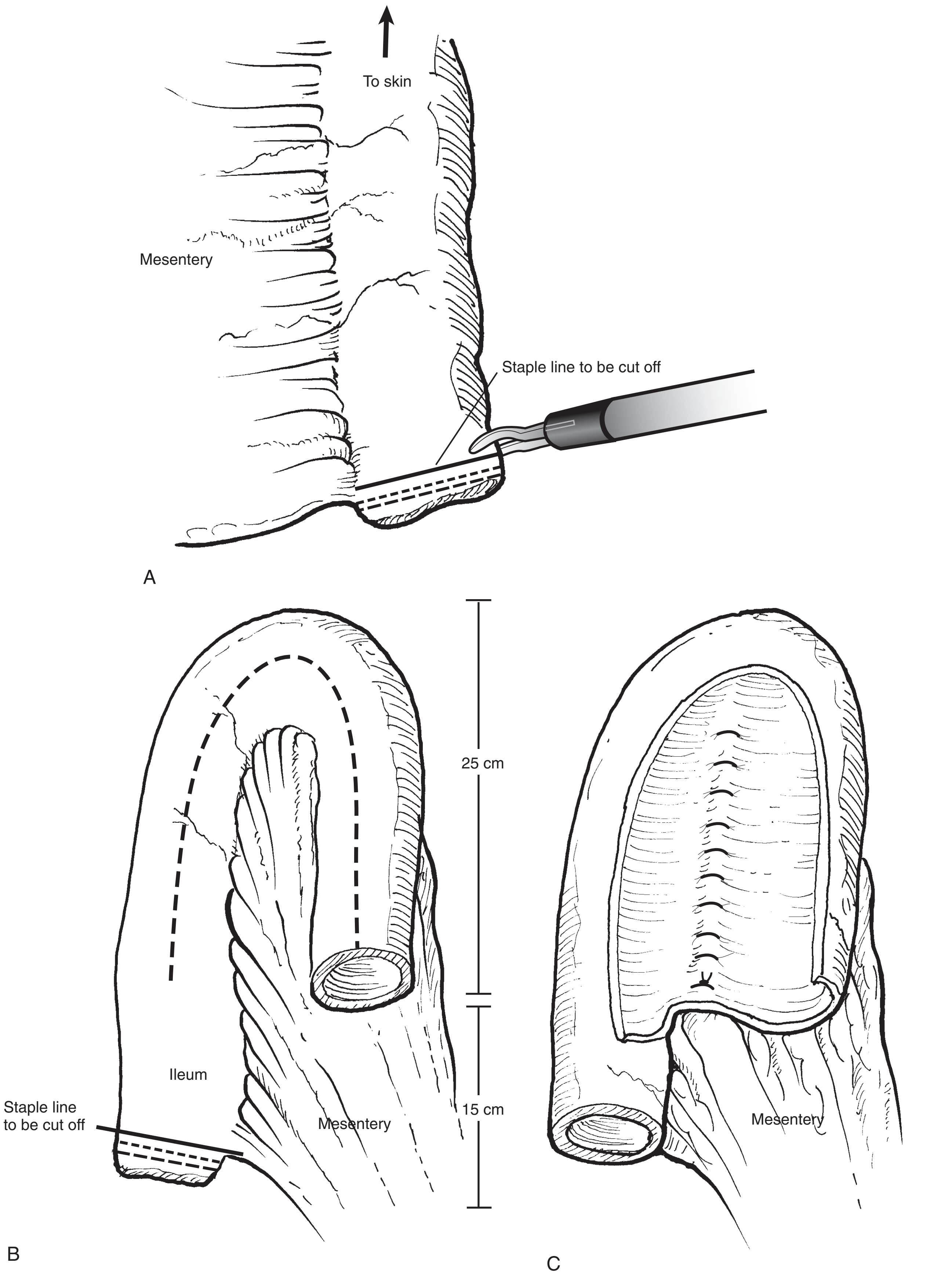

FIGURE 25–15. *A,* Ureteroileal reanastomosis. Cutting off the staple line may prevent stone formation in the conduit butt end and allows for Wallace reanastomosis of the spatulated ureters (see *D*). *B,* For a neobladder, 65 cm of length is appropriate, starting about 15 cm away from the ileocecal valve. *C,* The distal 50 cm of the chosen bowel segment is detubularized, the posterior wall is stitched together, and a new aperistaltic reservoir is created.

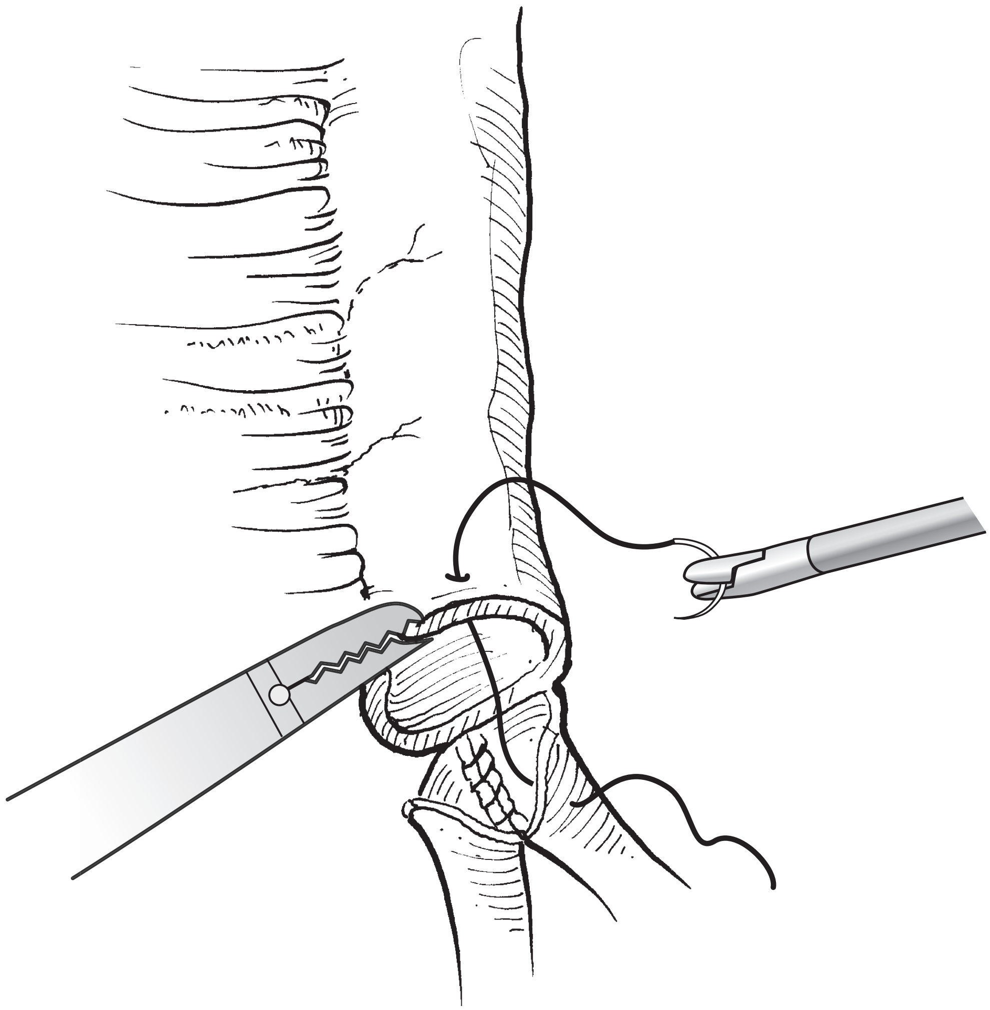

FIGURE 25–15, cont'd. *D,* Wallace anastomosis of the spatulated ureters.

confirm that there no leakage from the neobladder or ureteral anastomoses. This is followed by removal of the suprapubic catheter. Patients are discharged home when they are passing flatus, tolerating a regular diet, afebrile, and ambulating easily and have their pain well controlled with oral medications.

COMPLICATIONS

In general, the complications resulting from LRC and urinary diversion mimic those of the open procedure. It should be noted, however, that because LRC has only recently been performed and available series are small, there is very little information on either the long-term functional results or complications. We know from large open series that 30% of patients have subacute complications and 30% have chronic complications.[1,16] Here we review the known complications of LRC and the potential complications that are well known from the open surgery literature.

Intraoperative Complications

Major vascular injury has been reported during LRC.[5,17] Excessive bleeding can also occur despite apparently good vascular pedicle control.[4] The lymph node dissection can result in both vascular injury or obturator nerve injury due to their proximity to this dissection. Bowel injury can occur during laparoscopic access as well as during dissection or reflection of the colon. The use of thermal energy must be avoided adjacent to bowel, and even minor bowel injuries should be oversewn. Delayed laparoscopic bowel injuries often present with leukopenia, severe pain over the trocar site nearest the injury, and diarrhea. Ileus, leukocystosis, and classic peritoneal signs are unusual.[18] If necessary, bipolar cautery or laparoscopic clips are used for hemostasis of mesenteric bleeding. Rectal injury has also been reported during LRC[17,19] and is most common during prostate apical dissection or dissection of Denonvillier's plane between prostate and rectum. If injured, the rectum is oversewn, and omentum, if available, is brought down as an interposition. As stated previously, hypercapnia, acidosis, cardiac dysrhythmias, and fluid overload can occur during prolonged

procedures, especially in those with preexisting cardiopulmonary disease.

Subacute and Chronic Complications

All of the known subacute complications of open cystectomy can occur after LRC. Those that have been reported following LRC include deep venous thrombosis, pelvic abscess, small bowel obstruction, port site hernia, lymphocele, wound dehiscence, epididymal abscess, anastomotic leakage, ureteral obstruction, gastrointestinal hemorrhage, urinary tract infection, pyelonephritis, obturator nerve paresis, and pouchitis.[4,5,6,19]

Other long-term complications known to occur after cystectomy with urinary diversion include calculus disease, stomal stenosis, anastomotic contracture of ureter or urethra, electrolyte disturbances, and acidosis.

Tips and Tricks

- *Identify the ureters early* and follow them toward their bladder insertion. Keep a generous margin of tissue on them and minimize tissue manipulation.
- Perform the bulk of the posterior dissection *before* dropping the bladder.
- Fill the bladder with 120 mL or more of saline to help drop it safely.
- Use traction and countertraction throughout the case to help identify and dissect structures. Ultrasonic heat and electrocautery more effectively transect tissues that are under mild traction.
- On taking the pedicles, aim the roticulating endo-GIA toward the urethra *medially* and *anteriorly* rather than laterally and/or posteriorly to avoid rectal injury and to allow for sparing the proximal portions of the neurovascular bundles.
- Extracorporeal techniques that urologists are familiar with can be used to perform the lymphadenectomies and fashion the urinary diversions after laparoscopic cystectomy, although the neobladder-urethral anastomosis following orthotopic diversion may be facilitated by intracorporeal suturing techniques.

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CHAPTER 26

Laparoscopic Orchiopexy

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Earl Y. Cheng
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Now more than 10 years after its initial description in the management of cryptorchidism, laparoscopy is a well-accepted alternative to open exploration for the nonpalpable testis. Early experience proved that laparoscopy was a safe, minimally invasive means to identify and manage the nonpalpable testis.[1–6] More long-term data suggest promising outcomes that are indeed equivalent or superior to those of traditional open surgical techniques.[7–11] This chapter outlines both the preoperative considerations and the contemporary laparoscopic approach to the nonpalpable testis.

INDICATIONS AND CONTRAINDICATIONS

The vast majority of undescended testes will descend within the first 3 months; descent is far less common by 1 year of age. Furthermore, histologic evidence of potentially unfavorable changes after 12 months has resulted in recommendation for earlier orchiopexy.[12] Regardless of surgical approach, orchiopexy is generally reserved for children over the age of 6 months, avoiding the increased anesthetic risks for younger infants.[13] The palpable inguinal or high scrotal testis is traditionally approached via a small inguinal incision. When the testis is nonpalpable, diagnostic laparoscopy is indicated, with further therapeutic laparoscopy or open exploration dictated by the intraoperative findings. In cases in which the testis is palpable but high in the inguinal canal, some surgeons will augment their open approach with laparoscopic mobilization of the vas and vessels. This approach avoids extensive retroperitoneal dissection through the groin.[14]

Take care in the child with a previous history of extensive abdominal or pelvic surgery, significant cardiopulmonary disease, or other contraindications to either laparoscopic or open pelvic surgery or general anesthesia.

PATIENT PREOPERATIVE EVALUATION AND PREPARATION

The clinical finding of a unilateral nonpalpable testis will ultimately reveal one of four scenarios:

1. Intra-abdominal testis
2. Atrophic (“vanishing”) testis
3. High canalicular (“peeping”) testis
4. Agenesis of the testis

Apparent hypertrophy of the normally descended contralateral testis, when compared with the expected testicular size by age-specific nomogram, may suggest vanishing testis or agenesis.[15,16] Unfortunately, this is not universally predictive and definitive confirmation is required. There are also no reliable imaging modalities with proved significant specificity or sensitivity to guarantee whether a healthy testis is present, thereby confirming the need for surgical intervention. Although diagnostic imaging with ultrasound and magnetic resonance imaging may suggest the presence of a testis, failure to identify a testis does not obviate the need for surgical exploration.[8,17–20] To date, only laparoscopy can unequivocally diagnose the presence or absence of a unilateral intra-abdominal testis.[10]

Role of Hormonal Therapy

Hormonal therapy has been investigated for both diagnosis and treatment of nonpalpable testes. Human chorionic gonadotropin (hCG) injections have resulted in sufficient growth and descent to allow palpation of high testes and, in rare cases, have allowed full descent into the scrotum.[21,22] The use of hCG therapy for definitive treatment of cryptorchidism appears limited.

hCG stimulation does, however, have several potential roles in the management of nonpalpable testes. In patients with bilateral nonpalpable gonads, an increase in testosterone levels after hCG stimulation is indicative of functioning testicular tissue. In addition, hCG may cause partial descent of the testes, possibly simplifying subsequent orchiopexy. Even in the case of a unilateral nonpalpable testis, preoperative hCG may cause partial descent of the testis and therefore decrease the need for a Fowler-Stephens procedure. Furthermore, when hCG is used preoperatively, the spermatic vessels are often more substantial.[21,22] This effect may then reduce the risk of atrophy after extensive mobilization.

Informed Consent

Parents are advised of the standard laparoscopic operative risks of bleeding, infection, general anesthesia, hernia, air embolus, and injury to intra-abdominal or retroperitoneal viscera or vessels. Informed consent for orchiopexy specifically includes the risks of testicular atrophy and injury to the vas deferens or gonadal vessels. The potential for conversion to an open procedure, the need for orchiectomy, the need for a staged procedure, and the potential finding of agenesis or vanishing testis are also discussed.

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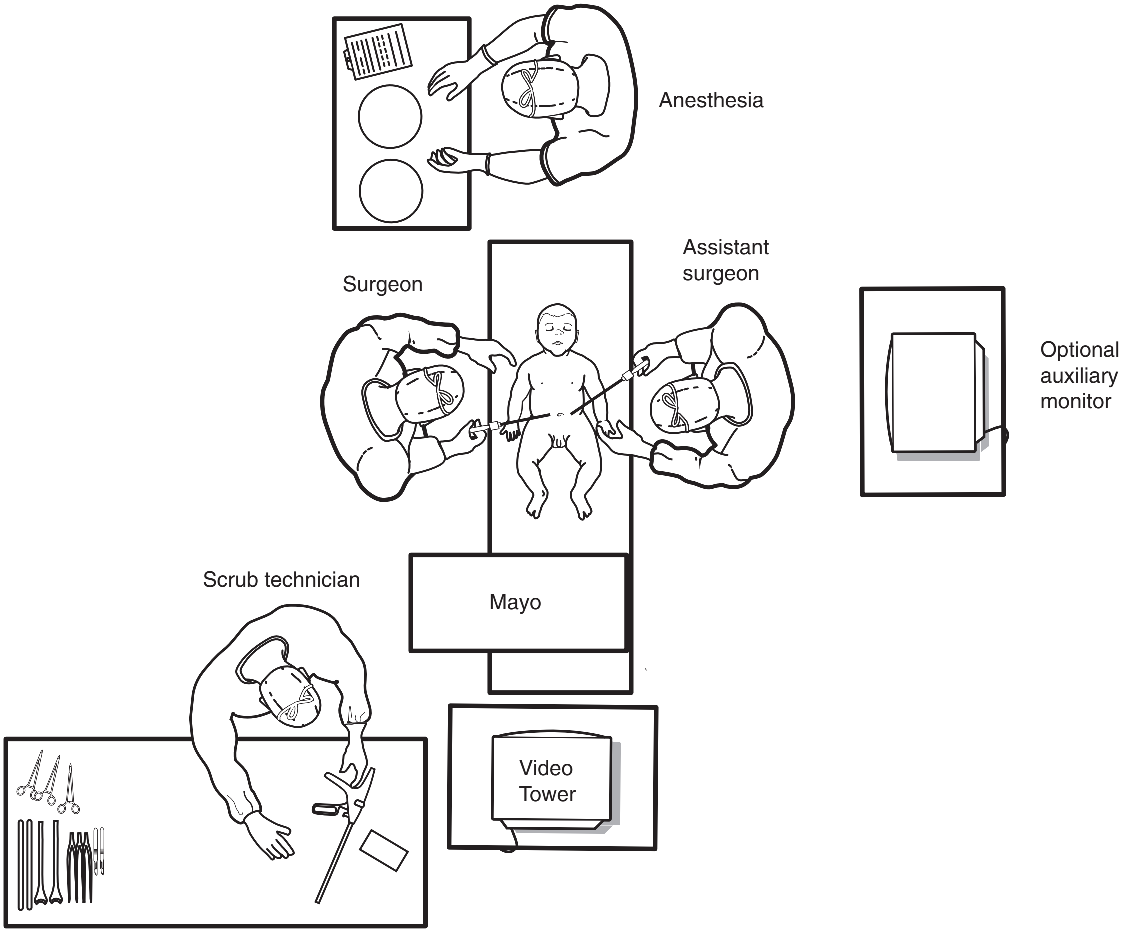


FIGURE 26–1. Operating room configuration. The monitor is placed at the foot of the bed to allow adequate visualization of the pelvis for the entire surgical team. The surgeon stands contralateral to the affected testis with an auxiliary slave monitor placed across the table for the primary surgeon.

OPERATING ROOM CONFIGURATION AND PATIENT POSITIONING

The operating room configuration includes one monitor at the foot of the bed to allow adequate visualization of the pelvis by all members of the surgical team (Fig. 26–1). Stand on the side contralateral to the affected testis. An auxiliary slave monitor may be placed across the table from the primary surgeon; however, when operating in the deep pelvis, we have found the monitor at the foot of the bed to be more ergonomic.

After induction of general endotracheal anesthesia, administer prophylactic broad-spectrum antibiotics and place a grounding pad. Leave the child supine with the legs parted moderately or frog-legged. Repeat examination of the groin under anesthesia may identify a testis and obviate the need for laparoscopic evaluation. Pad all pressure points without elevating the extremities to an extent that will compromise exposure to the scrotum or pelvis. Place a small smooth roll under the sacrum to elevate and open the pelvis, if needed.

Prep and drape the child from the xiphoid to the upper thighs. Use an orogastric tube to decompress gases from a tearful separation and induction of anesthesia. Place a urethral catheter after the sterile prep and leave it indwelling throughout the case.

TROCAR PLACEMENT

Three ports are generally sufficient to complete the procedure, with a rare fourth port needed to retract bowel or other obstructing structure. Place the first trocar in an immediate supraumbilical or infraumbilical position, as described later. Increase the peritoneal pressure temporarily to 20 mm Hg for insertion of additional trocars under direct visualization, if desired. Place the second and third ports, each 3 mm or 5 mm depending on available equipment, at the level of the umbilicus in the mid-clavicular line (Fig. 26–2). The vector of each trocar is toward the affected groin. Take care to avoid the epigastric vessels. Placement of these ports just above the level of the umbilicus instead allows additional room for movement of instruments in the smaller infant. This configuration affords freedom for the surgeon and camera without compromising the triangulation needed for the laparoscopist to work efficiently.

Once optimally positioned, secure each trocar to the a bdominal wall with suture to prevent inadvertent withdrawal during instrument exchange. Trendelenburg positioning with table rotation to the unaffected side will facilitate displacement of the bowel for safe visualization of the anatomy.

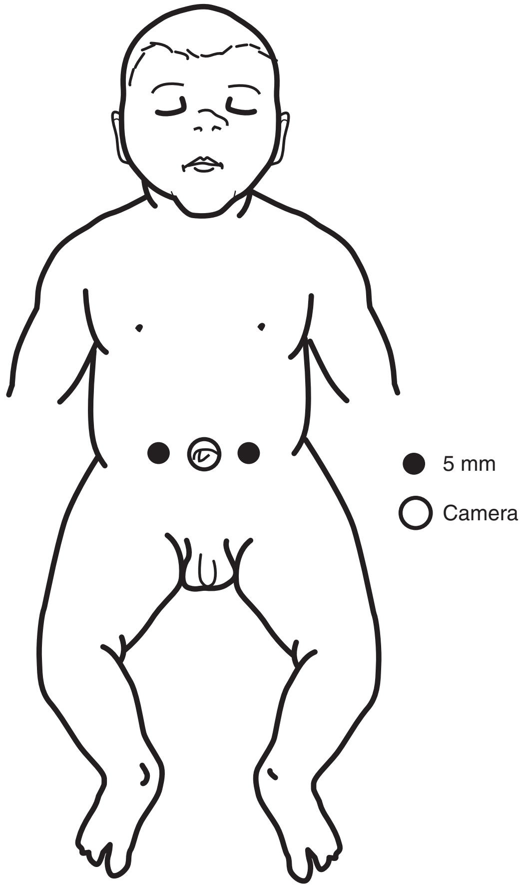


FIGURE 26–2. Trocar placement. A periumbilical port is initially placed, with second and third ports placed at the level of the umbilicus in the midclavicular line.

PROCEDURE

Diagnostic Laparoscopy

Achieve peritoneal insufflation in children via a small semilunar incision in the infraumbilical or supraumbilical rim or by a transumbilical approach; excellent cosmesis results in each case. Obtain access to the peritoneum via direct blind puncture (Veress needle technique) or open insertion (Hasson trocar technique). Insert the trocar at a 45-degree angle toward the pelvis to minimize the risk of visceral injury. These techniques and respective precautions are described in detail elsewhere in the text, and the approach largely depends on the training and preference of the surgeon. After insertion of a 5-mm umbilical port, perform CO_2 insufflation at low flow to achieve a pressure of 12 mm Hg in infants and 15 mm Hg in the older child. Use disposable or reusable trocars. Radially dilating introducers are also useful for insertion of trocars. Defer placement of additional ports until the gonad is identified and plans for therapeutic laparoscopy are in place.

After safely entering the peritoneal cavity, briefly inspect the abdominal and pelvic contents to rule out injury or obvious coincident pathology. Rare adhesions may be encountered in the pelvis in children with a history of prior abdominal operation or infection. Perform careful dissection with either the EndoShears or ultrasonic dissector to facilitate exposure.

The inguinal ring may be more difficult to see in the child with a high abdominal testis because the anatomic landscape is less populated. The contralateral ring is a useful reference in that situation. The normal inguinal ring is marked by the confluence of the vas deferens (medial) and spermatic vessels (lateral) (Fig. 26–3). Their relationship with the iliacs and ureter, as well as the obliterated umbilical artery and inferior epigastric vessels, is also noteworthy for the progression of the case.

The vas deferens travels in the retroperitoneum in the deep pelvis, crossing the obliterated umbilical artery laterally and the distal ureter medially after exiting the deep inguinal ring. The spermatic vessels come into view from just beneath the ipsilateral colonic peritoneal reflection and follow a retroperitoneal course toward the internal inguinal ring (see Fig. 26–3). The vessels guide the surgeon to the testis, which can be anywhere along the course of normal testicular descent from the renal hilum to the pelvis. Uncommonly, the testis may be found near the liver or spleen, in the deep pelvis behind the bladder, or ectopic in the contralateral hemipelvis. The vas deferens, gonadal vessels, and testis compose a triangle, with the testis at the apex. This triangle serves as the platform for the posterior peritoneal dissection and pedicle mobilization.

Intraoperative Decisions

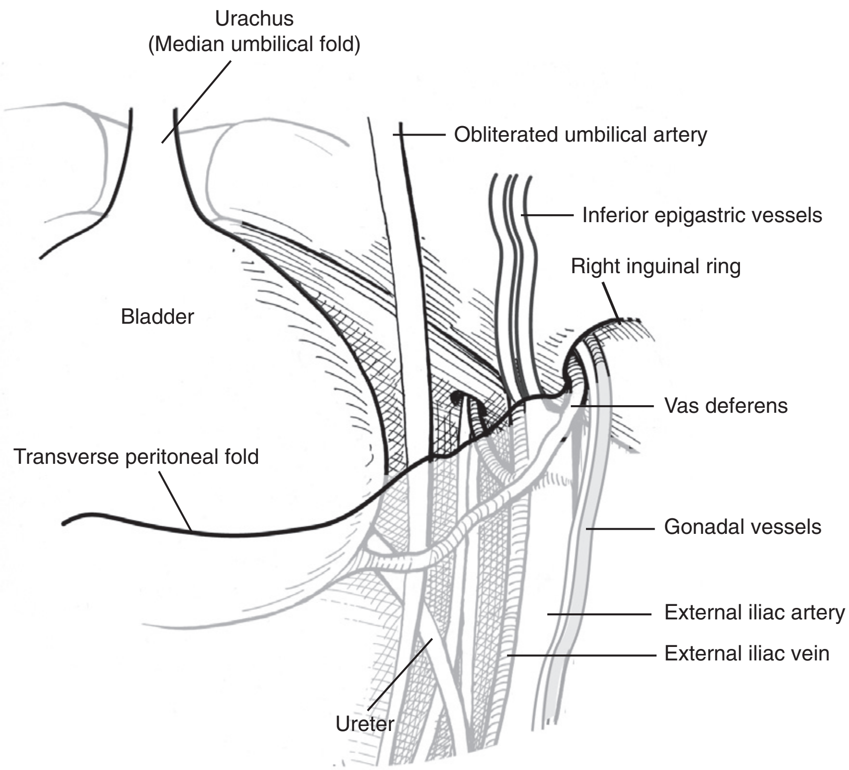
The next phase of surgical intervention depends on the findings during laparoscopic exploration; potential scenarios are outlined as follows.

1. *An intra-abdominal testis is identified.* If the testis is located near the internal ring or below the level of the iliac vessels, one-stage laparoscopic orchiopexy is appropriate. However, for a very high testis with a short vascular leash, consider a two-stage procedure before extensive dissection (see discussion of two-stage laparoscopic Fowler-Stephens).
2. *A normal vas deferens and spermatic vessels exit the inguinal ring.* If the inguinal ring is closed, explore the groin for a probable vanishing testis. The need for excision of these remnants is controversial but recommended, because the “nubbin” contains viable germ cell elements in 10% of cases.[23,24] If the inguinal ring is open, a “peeping” testis may be located just inside the canal and may be milked into the abdomen for laparoscopic mobilization. Otherwise, perform inguinal exploration.
3. *Blind-ending vas and vessels are identified.* This is the only scenario in which no further exploration is required.
4. *Blind-ending vas is identified.* Further laparoscopic exploration is required to identify the gonadal vessels. Dysjunction can occur between the testis and Wolffian structures; if a testis is present, it will be related to the vessels. Blind-ending vessels are required to terminate exploration.

Components of Laparoscopic Orchiopexy

After peritoneal insufflation and identification of a low intra-abdominal or a “peeping” testis at the internal ring, laparoscopic orchiopexy is completed with the following basic steps:

1. Place trocars (see earlier).
2. Dissect the testis and vascular pedicle.
3. Create the Dartos pouch.



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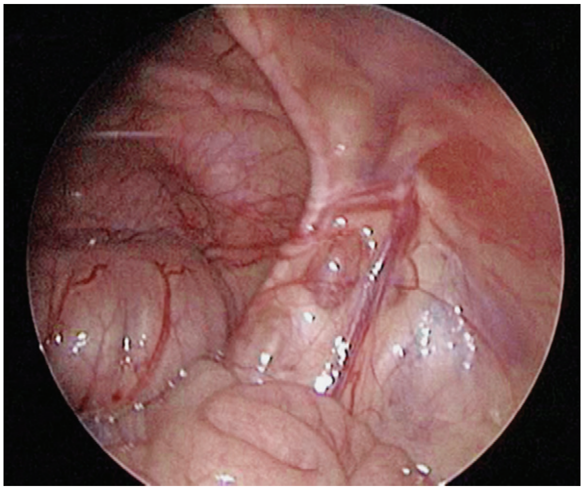

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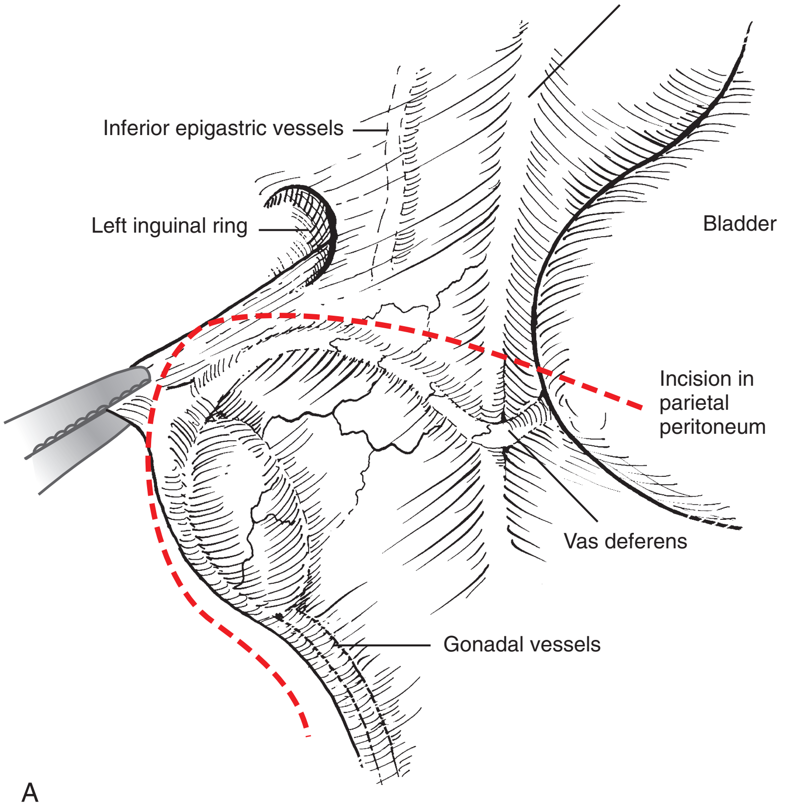
FIGURE 26–3. *A* and *B,* Normal right inguinal ring. Note confluence of vas deferens and vessels at the internal ring. The inferior epigastric vessels and obliterated umbilical artery are clearly visualized.

4. Perform the laparoscopic Prentiss maneuver.
5. Deliver the testis with orchiopexy.

Dissection of the Testis and Vascular Pedicle

The triangle of the vas deferens, testis, and gonadal vessels provides guidance for the dissection of the parietal peritoneum off the pelvic floor and side wall. Using a fine laparoscopic grasper, elevate a fold of peritoneum lateral to the gonadal vessels. Incise the peritoneum, with the dominant hand using EndoShears or the ultrasonic dissector, parallel to the gonadal vessels toward the ipsilateral internal inguinal ring. Grasp the peritoneum just distal to the testis and retract it cranially to expose the gubernaculum and processus vaginalis. Thin these tissues before dividing them in order to avoid injury to a long-looping vas. Use electrocautery or ultrasonic coagulation to divide the vascular gubernaculum (Fig. 26–5). Incise the peritoneum medial and parallel to the vas deferens as well, and bluntly mobilize the peritoneal triangle from the underlying iliac vessels, ureter, and obliterated umbilical artery. Preserve the peritoneal triangle between the vas deferens and the spermatic vessels as much as possible because this maximizes the blood supply to the mobilized testis.

Assess adequacy of pedicle mobility and length by guiding the mobilized gubernacular remnant and testis toward the contralateral inguinal ring (Fig. 26–6). If the testis can safely reach this landmark, typically it can be placed in the scrotum without tension. If the testis cannot reach the contralateral ring, further



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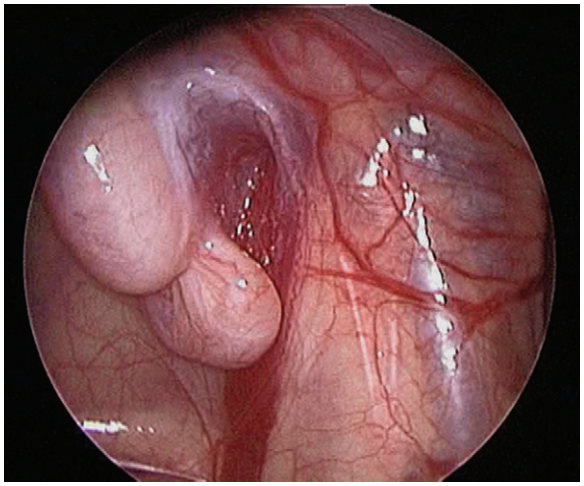


B

FIGURE 26–4. *A,* The vas deferens, gonadal vessels, and testis compose a triangle covered by peritoneum, with the testis at the apex of the triangle. This peritoneal triangle is scored for dissection of the testis, vas, and gonadal vessels. *B,* Left abdominal testis at internal ring. Note prominent vascular leash in retroperitoneum.

proximal dissection is required. Continue the peritoneal incision lateral and parallel to the gonadal vessels, at times requiring reflection of the ipsilateral colon. High transverse incision of the peritoneum over the gonadal vessels (perpendicular to the axis of the vessels) may relax the pedicle for further length. Again, take care to minimize incision of the peritoneum distally between the vas and vessels.

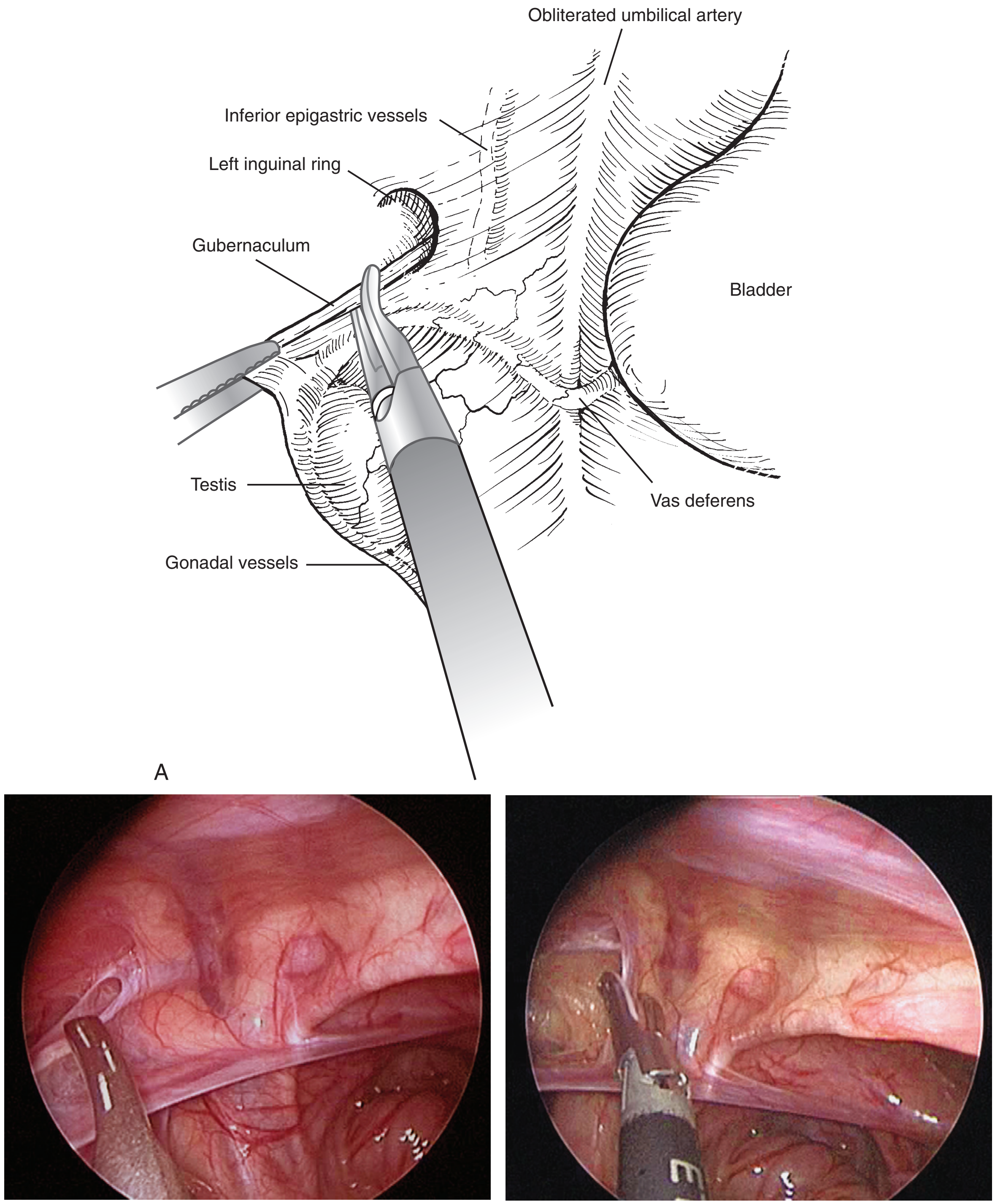
If mobility is still suboptimal, perform a one-stage Fowler-Stephens laparoscopic orchiopexy. Doubly clip and divide the gonadal vessels well above the confluence of the vas and vessels. Then deliver the testis to the scrotum, as described later, relying on the vasal artery for survival.

Creation of the Dartos Pouch

Create the Dartos pouch through a 1-cm ipsilateral midscrotal incision along natural skin folds. Create this subcutaneous pouch with fine scissors or a fine hemostat, taking care to avoid dissection into the true hemiscrotum.

Laparoscopic Prentiss Maneuver

Once the Dartos pouch is adequate, deliver the testis anterior to the pubic tubercle and into the scrotal incision. This maneuver is facilitated by firm but gentle penetration of the anterior



B C

FIGURE 26–5. *A* and *B*, Division of the gubernaculum. Traction is applied to the gubernaculum, which is divided with electrocautery or ultrasonic coagulation. *C*, Incise the peritoneum medially parallel to the course of the vas deferens. The peritoneal triangle is developed and mobilized from the underlying iliac vessels, ureter, and obliterated umbilical artery.

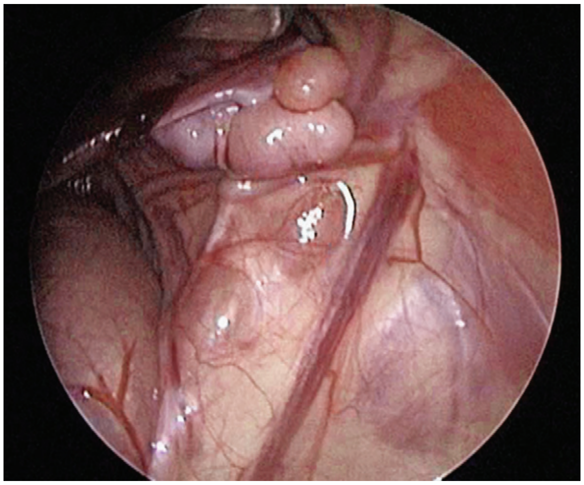


FIGURE 26–6. Verify that mobilized testis can reach contralateral ring.

abdominal wall fascia with a laparoscopic Maryland grasper, just medial to the inferior epigastric vessels but lateral to the obliterated umbilical artery (Prentiss maneuver) (Fig. 26–7). This effectively creates a new inguinal canal for surgical descent of the testis, decreasing the length of pedicle needed to reach the scrotum. Verify adequacy of urethral catheter drainage before performing this maneuver in order to avoid bladder injury. Guide the grasper through the Dartos pouch and out the scrotal skin incision. Grasp a 5- or 10-mm radially dilating introducer sheath with this instrument and guide it into the pelvis under direct visualization from the peritoneum. Alternatively, if a radially dilating trocar system is not available, use a set of Amplatz dilators to develop the neocanal.[25]

Delivery of the Testis With Orchiopexy

Advance a trocar through the sheath in the neocanal, and advance a locking grasper through the scrotal trocar into the peritoneum (Fig. 26–8). Apply gentle traction on the gubernaculum to guide the testis over the pubis and through the scrotal incision while removing the trocar. If a 10-mm port is selected for scrotal access, the testis can typically be drawn safely into the trocar for smooth delivery into the scrotum. Endoscopically monitor descent of the testis into the scrotum from above to ensure delivery without torsion of the pedicle.[26] Fix the testis within the Dartos pouch according to surgeon preference for open orchiopexy.

Decrease the insufflation pressure and examine the field for active bleeding. Close the fascial port sites to avoid hernia and inject the incisions with bupivacaine.

Two-Stage Fowler-Stephens Laparoscopic Orchiopexy

First Stage

When an intra-abdominal testis is too high to bring down into the scrotum without excessive tension, perform a Fowler-Stephens orchiopexy.[27] In the first stage, advance a 5-mm laparoscopic clip applier to ligate the gonadal vessels en bloc. A limited peritoneotomy medial to the vessels allows ligation without extensive dissection (Fig. 26–9). Use the ultrasonic dissector to divide the vascular pedicle without incision of the peritoneum, if desired. Alternatively, place the fully mobilized testis and its divided vessels deep in the pelvis in the vicinity of the inferior epigastric vessels. In this case, although the testis is well positioned for the second stage, the secondary adhesions may complicate the second-stage dissection.[9]

Second Stage

Final mobilization and delivery of the testis occur 6 months after the first stage.[28] This waiting period is intended to maximize the quality of the vasal circulation through collateral flow. Minimal adhesion formation is typical after simple ligation during the first stage.[29] Advise the parents that atrophy may have occurred and could result in orchiectomy during the second stage. Divide the clipped vessels, and proceed with peritoneal mobilization as described earlier for standard laparoscopic orchiopexy. Take great care to preserve the peritoneal triangle and all perivasal tissues.

One-Stage Fowler-Stephens Laparoscopic Orchiopexy

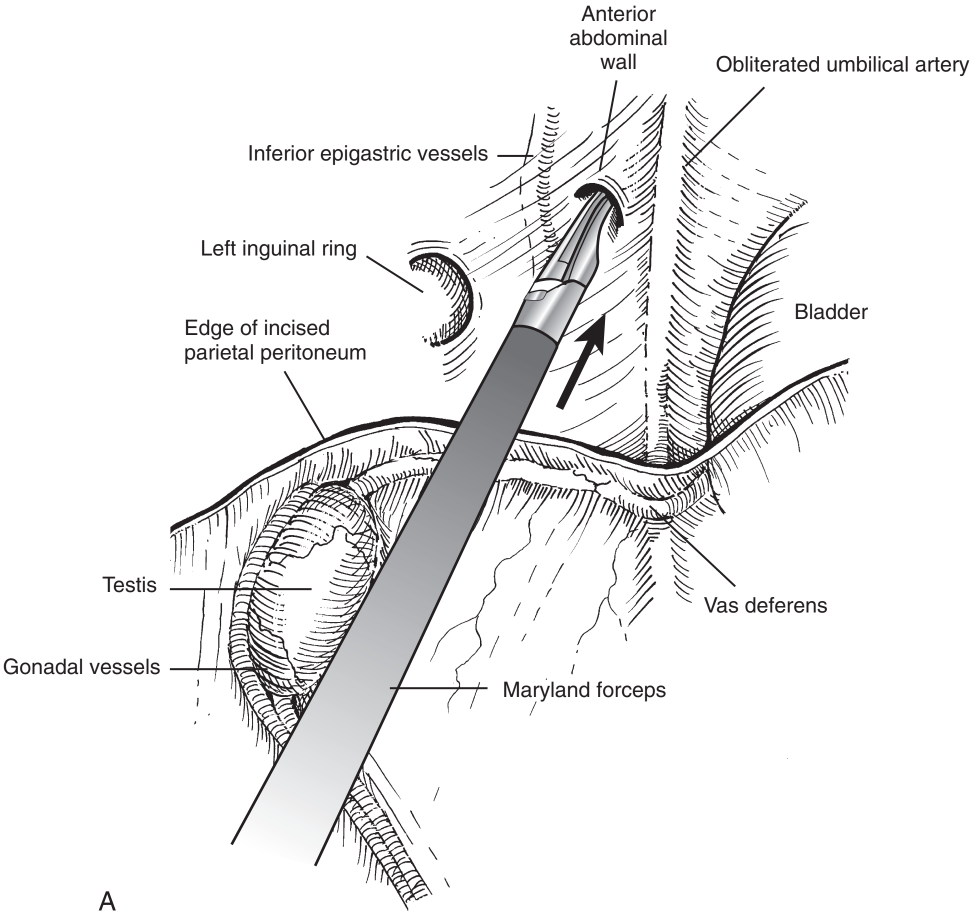
Some surgeons prefer to perform gonadal vessel ligation and trans-scrotal delivery of the testis in the same setting, possibly increasing the risk of acute testicular atrophy. Once it is clear that the mobilized testis and pedicle have insufficient length to reach the scrotum, clip and divide the vessels. The remainder of the procedure is as described earlier for standard laparoscopic orchiopexy. Outcomes equivalent to those of two-stage procedures have been reported if no prior testicular mobilization has been performed.[9]

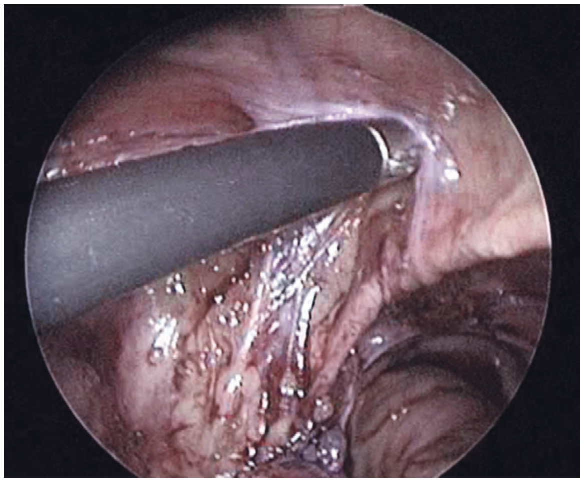
POSTOPERATIVE MANAGEMENT

Diet is advanced early in most cases, and the child is discharged from outpatient surgery. The child may bathe 48 hours after surgery. Straddle toys and rough play are not allowed for 3 weeks. Low-dose oral narcotics may be necessary for the first several days, followed by acetaminophen as needed. Routine follow-up at 1, 6, and 12 months is recommended. With any history of cryptorchid testis, monthly bilateral testicular self-examination is recommended after puberty.

Surgical Results

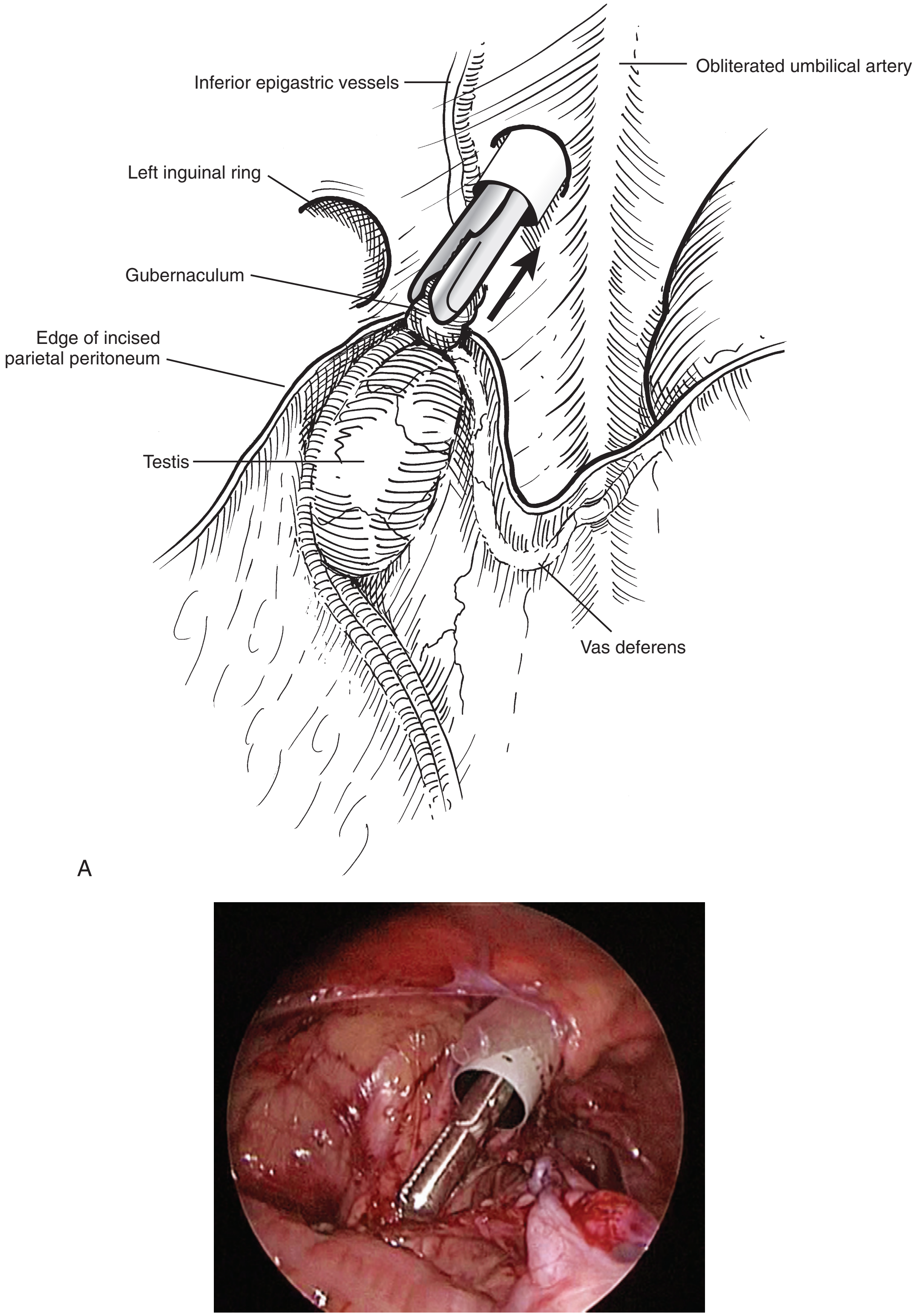
Validation of therapeutic laparoscopy in management of the intra-abdominal testis requires comparison to the gold standard of open surgical exploration. The desired technical outcome is a well-positioned scrotal testis without acute atrophy. Techniques must be stratified according to preservation or division of the gonadal vessels and whether a staged procedure is performed. Multi-institutional analyses comparing success rates of all open and all laparoscopic orchiopexy techniques for intra-abdominal testis favor the laparoscopic approach in all categories (81.3% versus 97.2% for primary orchiopexy, 76.8% versus 87.9% for two-stage Fowler-Stephens, and 66.7% versus 74.1% for one-stage Fowler-Stephens orchiopexy).[7,10] Clearly, it is more





B

FIGURE 26–7. *A* and *B,* Laparoscopic Prentiss maneuver. Maryland forceps facilitate gentle penetration of the anterior abdominal wall fascia, medial to the inferior epigastric vessels, but lateral to the obliterated umbilical artery.



A

B

FIGURE 26–8. *A* and *B,* Delivery of the testis. A locking grasper is introduced through a scrotal trocar to deliver the testis to the scrotum. Descent is monitored laparoscopically to ensure delivery without pedicle torsion.

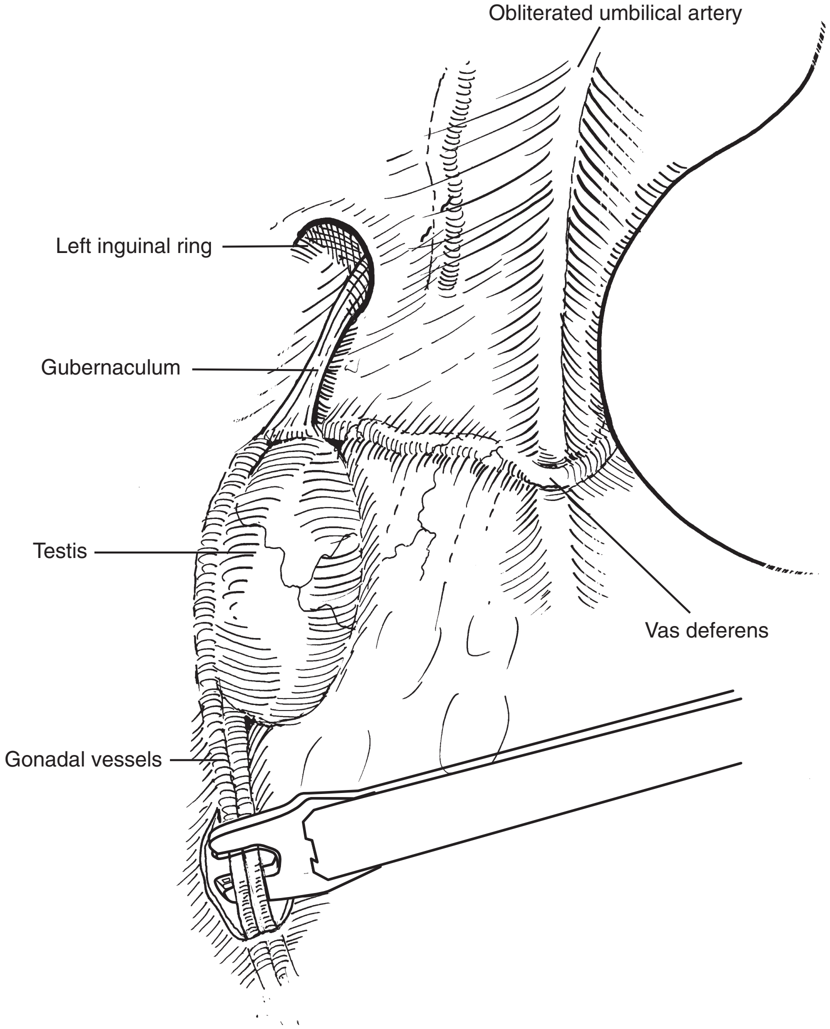


FIGURE 26–9. Fowler-Stephens maneuver. A 5-mm laparoscopic clip applier is advanced to ligate the gonadal vessels en bloc.

advantageous to leave the vessels intact, whether open or laparoscopic mobilization is elected. Some surgeons have had even more promising results with both one-stage and two-stage laparoscopic Fowler-Stephens orchiopexy. Atrophy occurred only in patients with prior exploration of the testis (11%). When division of the vessels is required, they prefer a one-stage procedure due to the risk of injury during tedious remobilization at the second stage.[9]

COMPLICATIONS

Aside from the incidence of testicular atrophy discussed earlier, operative complications are fortunately uncommon. Injury to abdominal viscera is more likely with blind insertion of a trocar after Veress needle insufflation than with open insertion of the initial trocar, particularly given the short distance between the anterior wall and the retroperitoneum in children. Injury to the bowel, bladder, great vessels, vas deferens, and gonadal vessels occurs infrequently.[9,10,30] Although closure of the internal inguinal ring is not routinely required,[28] indirect inguinal hernia has been reported.[31]

SUMMARY

Laparoscopy is becoming the standard for evaluation and subsequent management of the nonpalpable testis. Advantages over open exploration for intra-abdominal testes are improved visualization of anatomy, facilitation of wide mobilization, and a more direct course of the pedicle through uniform use of the Prentiss maneuver. The technique is accessible to all laparoscopic surgeons and offers a sound alternative to a traditional open exploration and mobilization. With both open and laparoscopic orchiopexy, risk of atrophy is directly related to the integrity of the vascular supply after mobilization of the testis.

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Pediatric Laparoscopic Pyeloplasty

CHAPTER 27

Paul H. Noh
Steven G. Docimo

Open pyeloplasty has long been the gold standard treatment of ureteropelvic junction (UPJ) obstruction. With the development of minimally invasive techniques, laparoscopic pyeloplasty has become more widespread as standard treatment in adults, with reports showing comparable results to the open procedure. Pediatric laparoscopic pyeloplasty has been slower to be adopted.[1] Laparoscopic pyeloplasty was first reported in 1993 by Schuessler and colleagues in five patients with good results.[2] Pediatric laparoscopic pyeloplasty was first described by Peters and associates in 1995.[3] Subsequent series in both adults and children have been reported including dismembered and nondismembered techniques as well as transabdominal versus retroperitoneal approaches.[4,5] The first series on robot-assisted pyeloplasty using a retroperitoneal approach in children was reported.[6] At Children's Hospital of Pittsburgh, a transabdominal laparoscopic dismembered pyeloplasty is routinely performed.

INDICATIONS AND CONTRAINDICATIONS

Patients diagnosed with UPJ obstruction are candidates for a transperitoneal laparoscopic pyeloplasty at Children's Hospital of Pittsburgh. The procedure is offered to families with infants as young as 6 months of age. Contraindications are consistent with those of any transabdominal laparoscopic surgery, including multiple previous open abdominal surgeries and poor pulmonary function.

PATIENT PREOPERATIVE EVALUATION AND PREPARATION

Routine preoperative evaluation includes a serum blood urea nitrogen and creatinine level and urine culture. Imaging studies typically include a renal ultrasound (Fig. 27–1*A*) and a nuclear diuretic renal scan for asymptomatic infants and often a computed tomography scan with intravenous contrast in symptomatic children (see Fig. 27–1*B*). An intravenous pyelogram is less commonly used (Fig. 27–2). A bowel prep is not routinely used. Symptomatic children may have a ureteral stent placement before a definitive repair.

OPERATING ROOM CONFIGURATION AND PATIENT POSITIONING

In a conventional operating suite, place a mobile tower with a video monitor on either side of the patient. In an operating suite designed for laparoscopy, also position monitors from a ceiling boom on either side of the patient. After gaining access and port placement, the surgeon and assistant stand on the side opposite of the surgical site. The CO_2 insufflator, camera, and light source are housed in the tower opposite from the surgeon.

Place the patient in a modified flank position at approximately 45 degrees with a log-shaped gel roll supporting the back (Fig. 27–3). Use a kidney rest, and use a flat gel pad as an axillary pad. Use a lateral arm board to position the upside arm. Secure the patient to the table with tape over the chest and hips. Place padding under all pressure points.

TROCAR PLACEMENT

Right Sided

For a right UPJ obstruction, three ports (5 mm or 3 mm) are typically used. Place a 5-mm camera port with an open technique at the umbilicus. Then place two working ports (5 mm or 3 mm), one in a subxyphoid midline position and the other in the left lower quadrant of the abdomen in the midclavicular line, under direct vision (Fig. 27–4*A*).

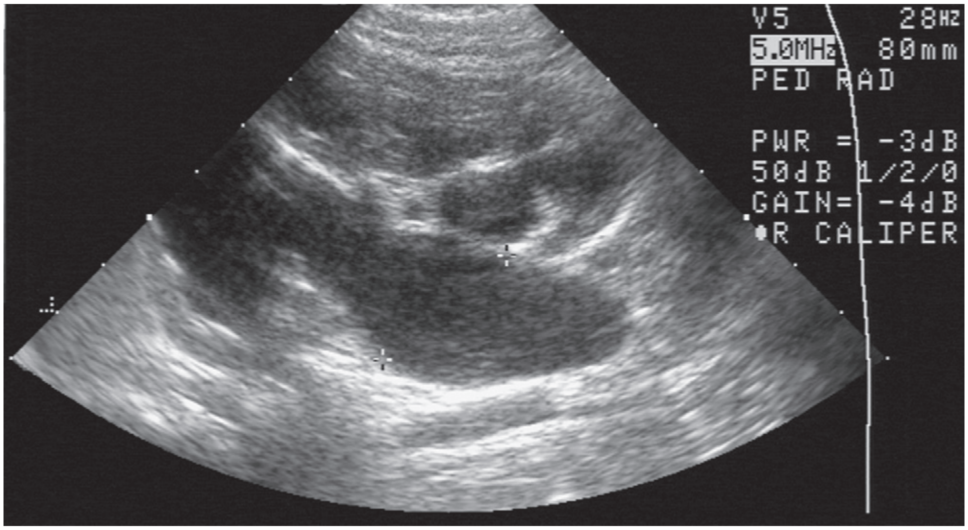
Left Sided

For a left UPJ obstruction, use three ports in a mirror image to the right-sided port placement (see Fig. 27–4*B*).

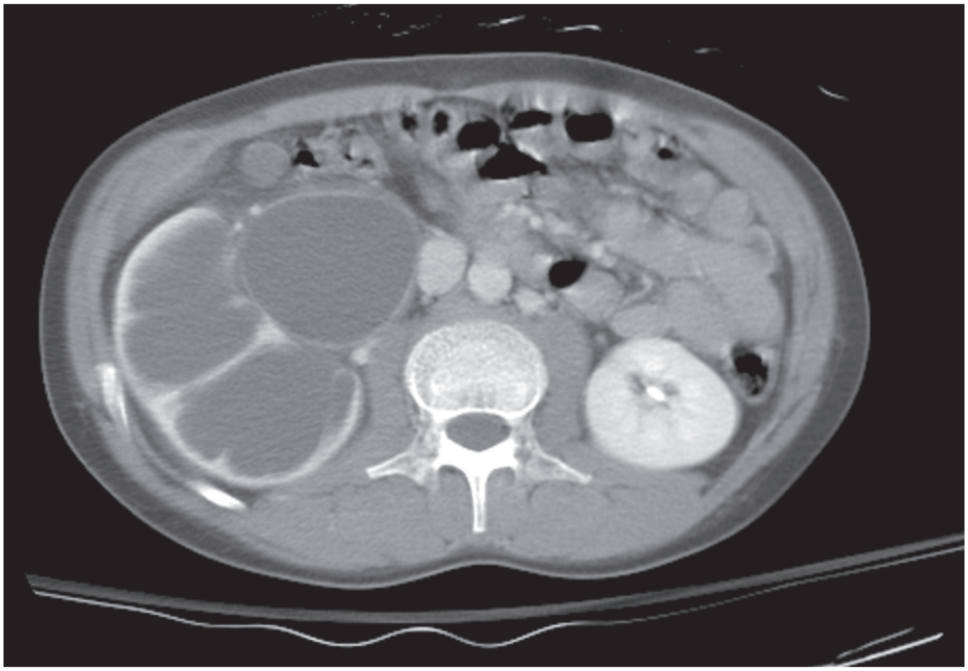
PROCEDURE

Perform cystoscopy with a retrograde ureteropyelogram (Fig. 27–5). After placement of a guidewire to facilitate ureteral identification and later stent placement, reposition the patient. Obtain open access through a hidden infraumbilical incision. Place a 5-mm port, secure it to the abdominal wall, and insufflate the abdomen. Use a 0-degree laparoscope to confirm intraperitoneal port placement. Place two additional working ports under direct vision and secure them to the abdominal wall. For a left UPJ obstruction, use a transmesenteric approach whenever possible (Fig. 27–6). Otherwise, as with a right-sided pyeloplasty, medially reflect the colon with sharp and blunt dissection. Use the psoas muscle as a landmark to maintain proper orientation. Identify the ureter and dissect it proximally toward the renal hilum; take care to identify possible crossing vessels (Fig. 27–7).

After limited mobilization of adventitial tissue around the pelvis and ureter, place a holding suture in the renal pelvis (Fig. 27–8). Introduce this suture through a port or pass it directly



A



B

FIGURE 27–1. *A,* Preoperative ultrasound. *B,* Computed tomography scan.

through the abdominal wall. If the suture is passed through a port, grasp the ends of the suture with a Carter-Thomason device, pass them out through the abdominal wall, and secure them with a hemostat to provide traction. Perform further mobilization, if necessary.

In the presence of crossing vessels, transect the UPJ with scissors below the vessels and then transpose the UPJ anterior to the vessels for the anastomosis (Fig. 27–9). If no crossing vessels are present, divide the ureter with a cuff of renal pelvis, which can be used as a handle (Fig. 27–10). The renal pelvis is not typically excised, nor is the UPJ, which allows for a more rounded apical anastomosis. Then laterally spatulate the ureter (Fig. 27–11).

Use a 6-0 polyglactin absorbable suture to start the anastomosis at the apex of the spatulated ureter (Fig. 27–12). Close one wall as a continuous running suture (Fig. 27–13). Use a second continuous suture to close the remaining wall (Fig. 27–14). Pass a double-J stent retrograde over the guide before completion of the anastomosis (Fig. 27–15). Place interrupted stitches, as necessary, to ensure a watertight anastomosis. Use intraoperative fluoroscopy to confirm proper stent positioning. Remove the holding suture, and allow the reconstructed UPJ to fall back into its normal anatomic position (Fig. 27–16). After inspection for hemostasis, remove the ports under direct vision. Close the umbilical fascia incision and all skin incisions.

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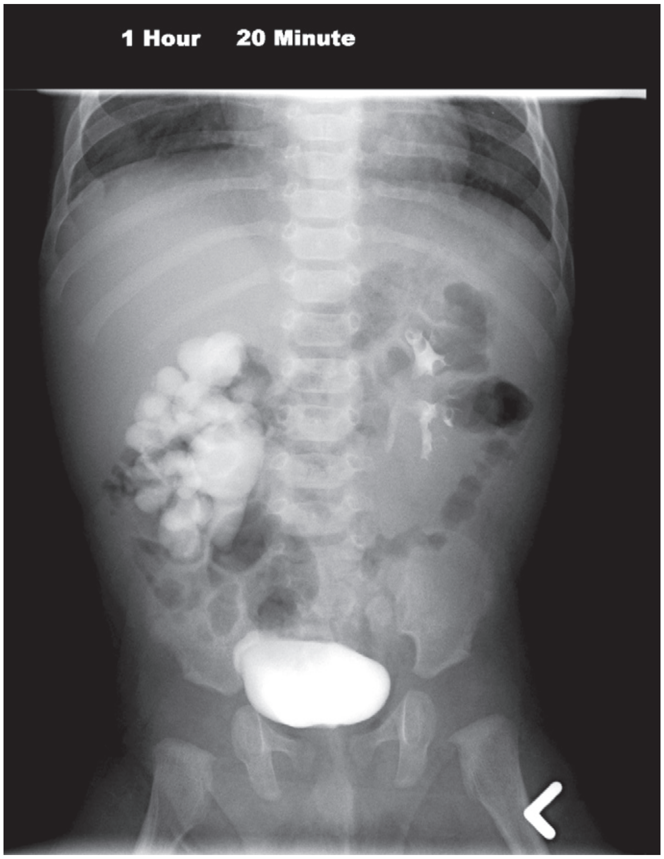


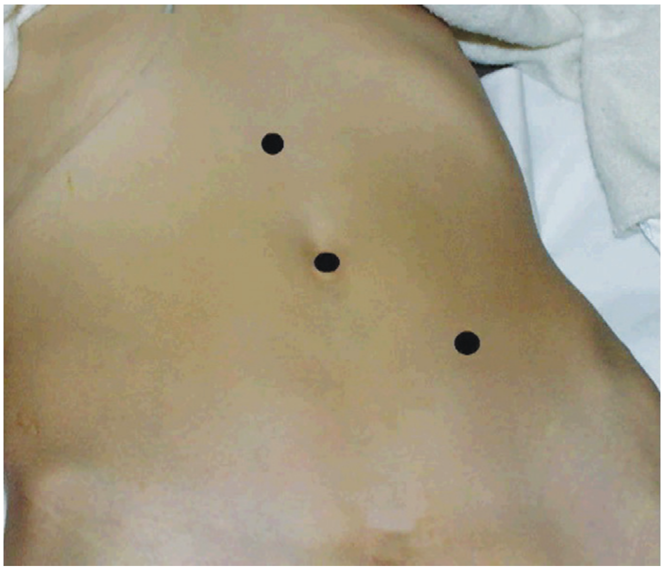
FIGURE 27–2. Intravenous pyelogram.

A

B

FIGURE 27–3. *A,* Patient in 45-degree position, secured to table with tape and use of axillary pad. *B,* Gel roll behind back to maintain 45-degree positioning.

A



B

FIGURE 27–4. *A,* Trocar placement for right pyeloplasty. Small dot is below right costal margin site of holding suture. *B,* Trocar placement for left pyeloplasty.

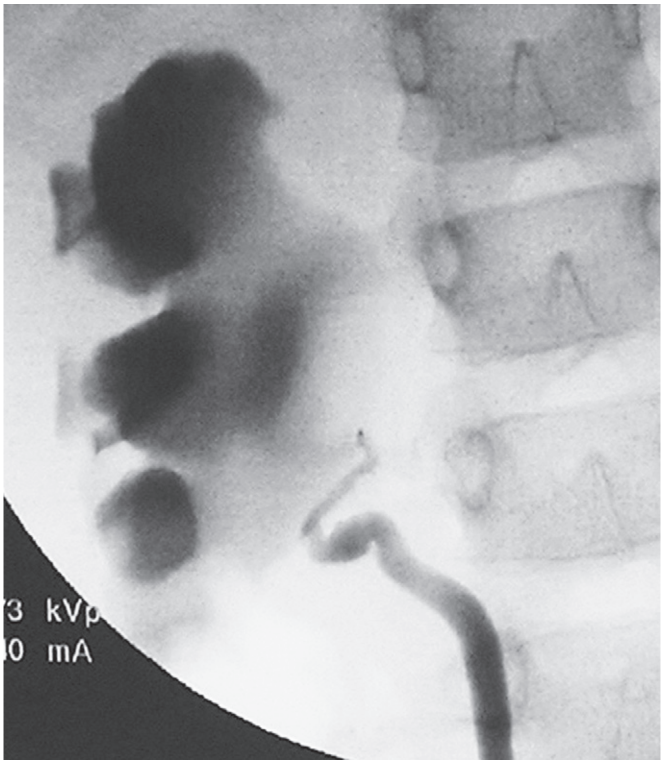


FIGURE 27–5. Intraoperative retrograde pyelogram demonstrating site of obstruction at ureteropelvic junction.

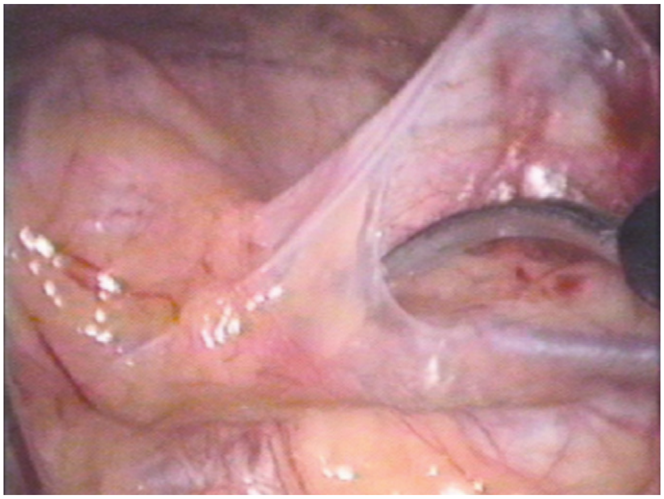


FIGURE 27–6. Dissection for transmesenteric approach for left ureteropelvic junction obstruction.

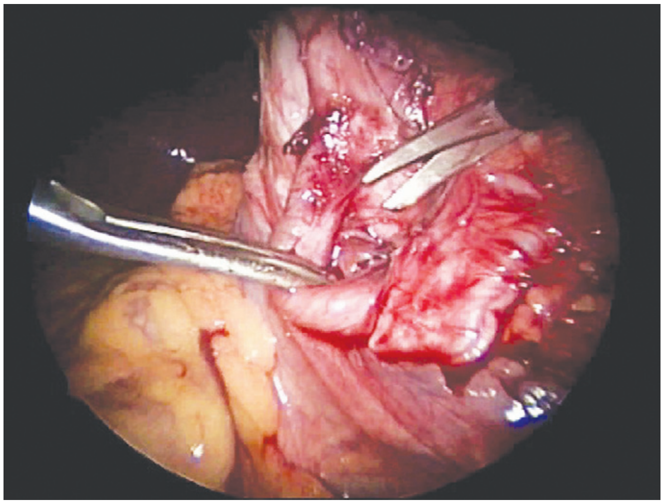


FIGURE 27–7. Dissection of crossing vessels.

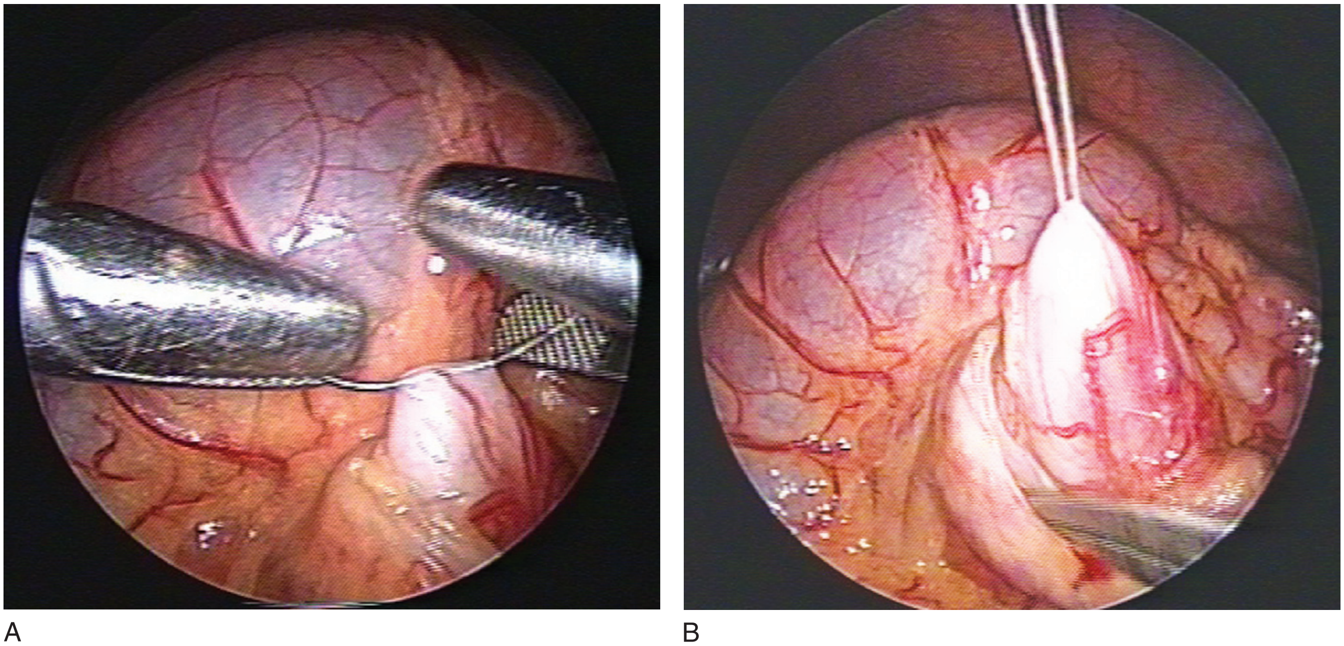


FIGURE 27–8. *A,* Holding suture placed in anterior wall of renal pelvis. *B,* Holding suture suspended through abdominal wall.

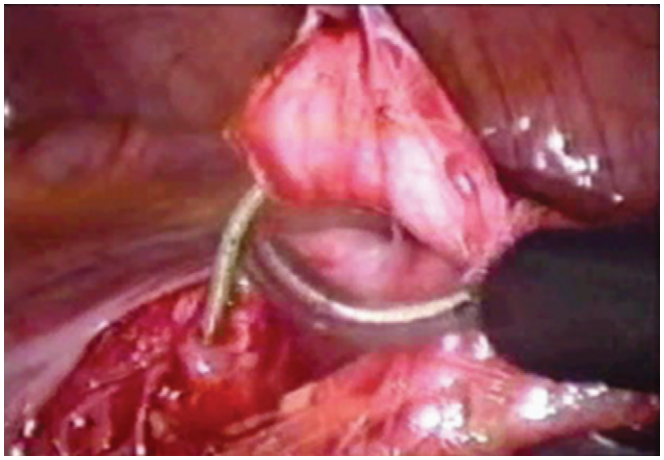


FIGURE 27–9. Ureteropelvic junction divided below crossing vessels.

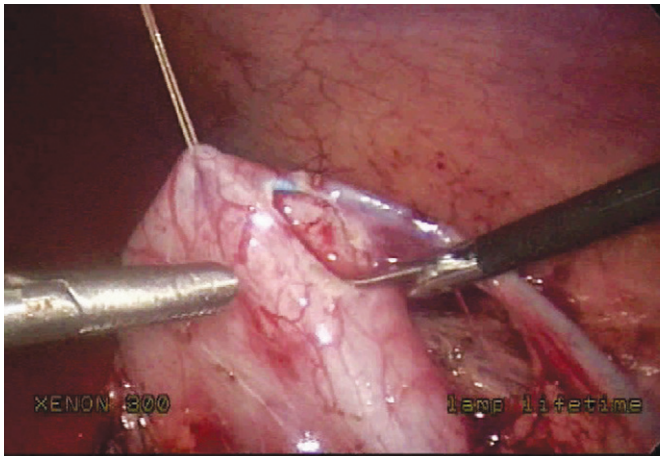


FIGURE 27–10. Division of ureteropelvic junction with cuff of renal pelvis.

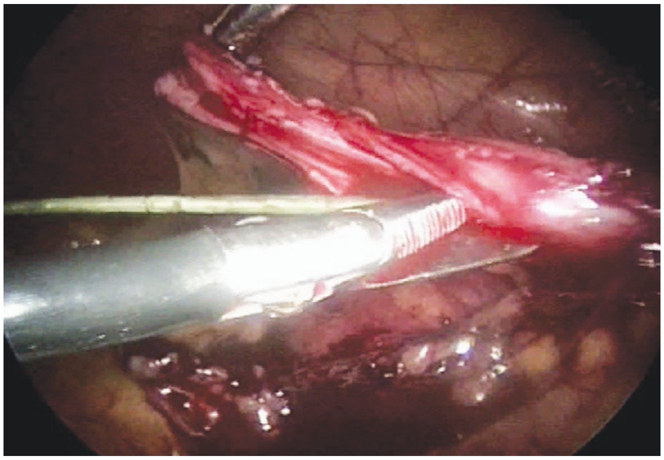


FIGURE 27–11. Sharp lateral spatulation of ureter.

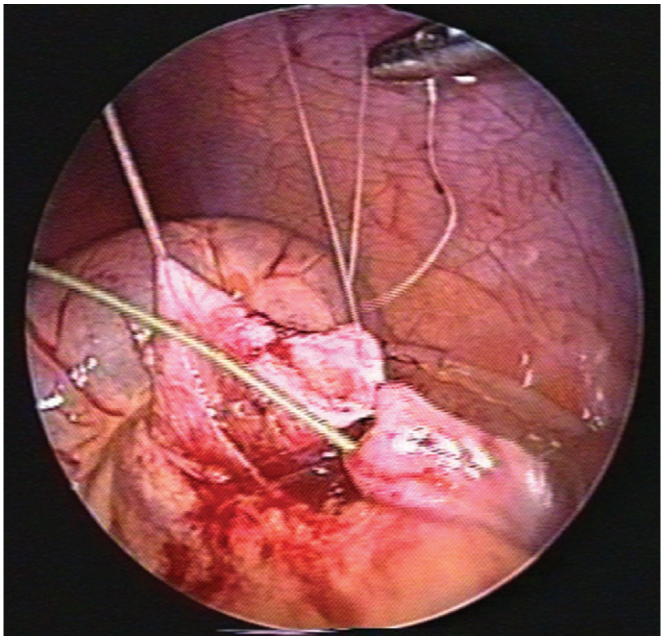
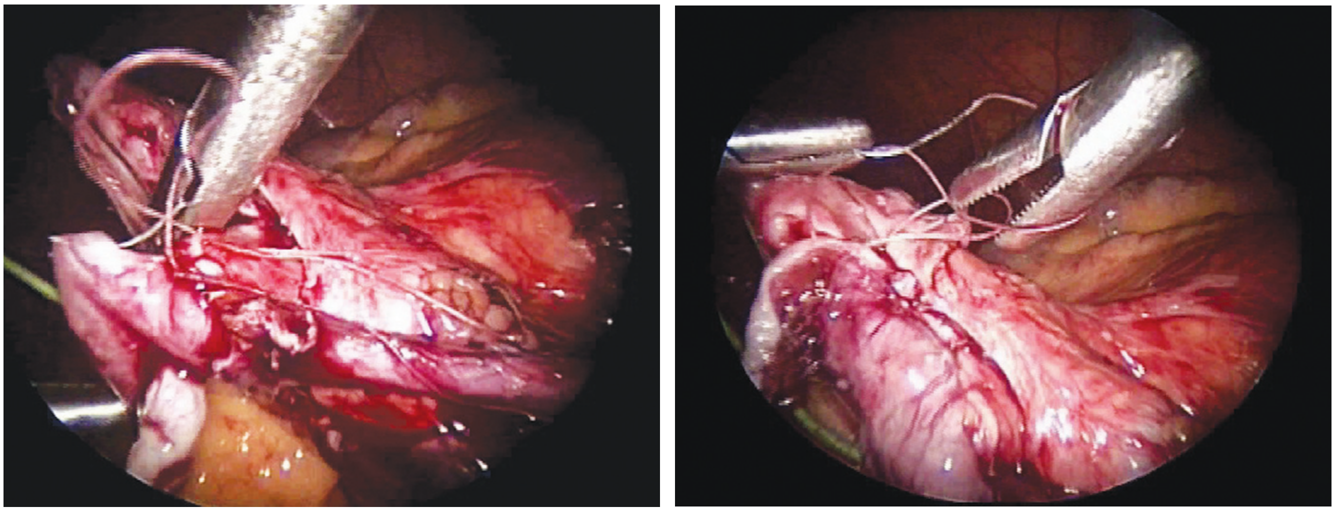


FIGURE 27–12. Apical suture to start the continuous running suture.



A

B

FIGURE 27–13. *A,* Needle passing through ureter for anterior wall anastomosis. *B,* Completed anterior wall anastomosis.

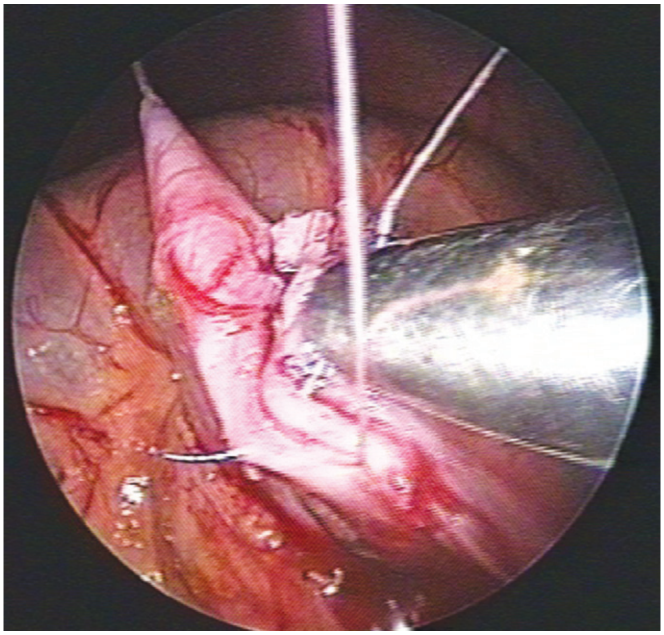


FIGURE 27–14. Ureter and pelvis in single throw for posterior wall running suture.

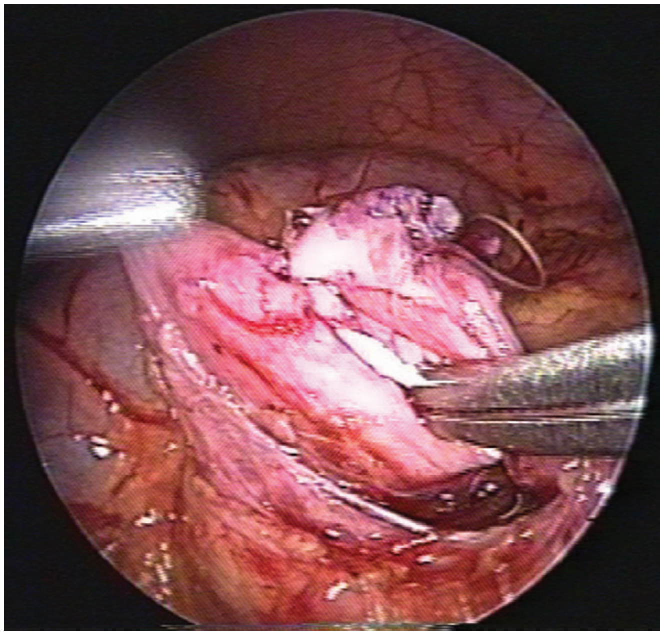
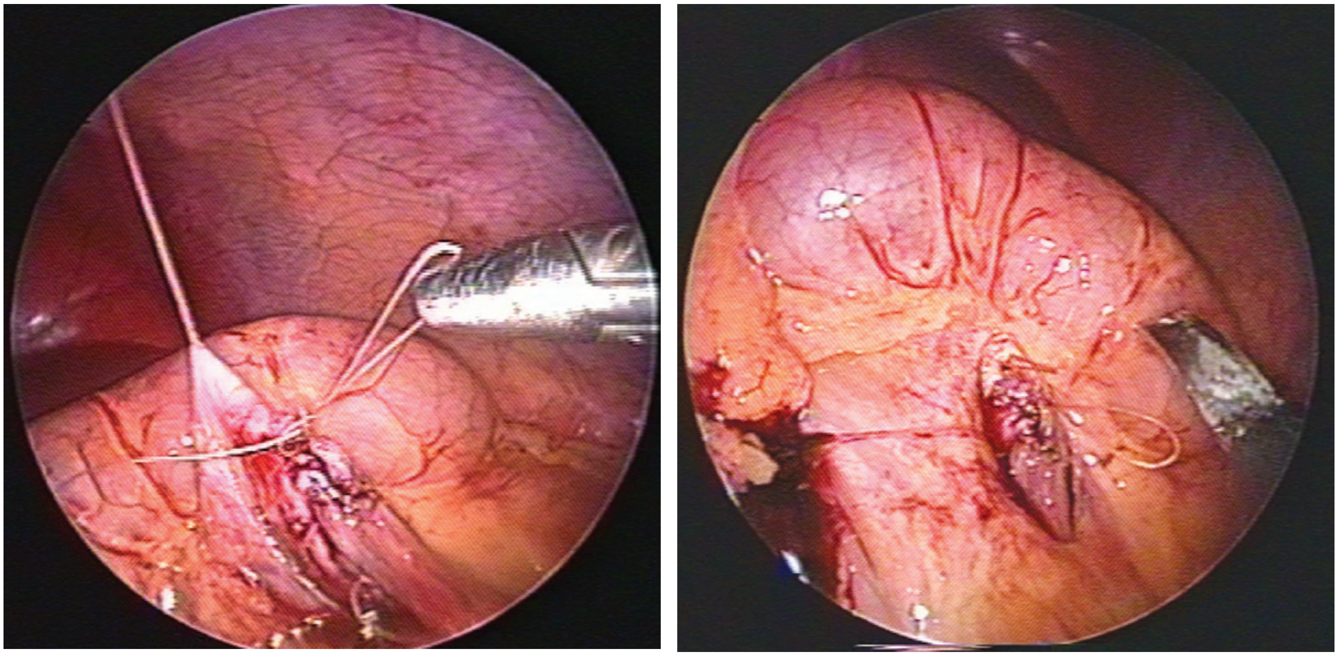


FIGURE 27–15. Double-J pigtail catheter visualized across the anastomosis before completion.



A B

FIGURE 27–16. *A,* Anastomosis completed. *B,* Holding suture removed and ureteropelvic junction back in its normal anatomic position.

POSTOPERATIVE MANAGEMENT

Patients have a Foley catheter placed for bladder drainage overnight. Clear liquids are started the evening of surgery. Analgesia consists of parental narcotics and ketorolac as necessary overnight. Oral narcotics are started on postoperative day 1. Patients are discharged home when tolerating liquids and pain is controlled, usually on postoperative day 1 or 2.

COMPLICATIONS

Bowel injury and bleeding are the most common intraoperative injuries.[7] Rare intraoperative complications such as pneumomediastinum and pneumothorax have been reported.[8] Postoperative complication rates have been reported as high as 12.7% in large series of laparoscopic pyeloplasty.[9] These include abdominal wall and trocar site hematomas, pyelonephritis, congestive

hear failure, pneumonia, ileus, thrombophlebitis, pulmonary embolism, ureteral stent migration, ureteral stent clot obstruction, ureteral edema, urinary leakage, urinoma, anastomotic stricture, and delayed stone formation.[5,7,9]

Tips and Tricks

- For right pyeloplasty, consider placing a working trocar in the midclavicular line in the upper abdomen to have both working trocars in line with the anastomosis for easier suturing.
- Consider additional traction or holding sutures at the apex and at the top of the anastomosis to align the ureter and pelvis for an improved, watertight anastomosis.
- For infant pyeloplasty, place working trocars as far apart as possible to minimize dueling of instruments.

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CHAPTER 28

Complications of Laparoscopic Surgery

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Louis R. Kavoussi

The benefit of any surgical intervention is weighed against the inevitable risk of complications. Although experience is of obvious importance, not even the most veteran surgeon is immune to complications that may occur during or after an operation. The potential for complications and unexpected events may arise from a multitude of sources, including the individuality of a given patient's anatomy, physiology, or disease. Variations in the operative environment, including staffing, anesthetic, and nursing issues, as well as equipment malfunction, also contribute to outcome. The possibility of a technical misadventure is also a constant risk. When complications do occur, early recognition and aggressive treatment are crucial in order to minimize subsequent morbidity to the patient.

Many of the complications that may occur during laparoscopic retroperitoneal surgery are similar to those encountered with traditional open surgery. However, controlling these events requires a unique skill set. Significant differences in the postoperative presentation of these complications may exist between the laparoscopic and open approaches. Moreover, some complications are unique to laparoscopic surgery. Fortunately, the tremendous growth of laparoscopy has allowed for a better understanding of the potential pitfalls associated with the endoscopic approach. Cumulative experience has helped to better quantify the risks associated with laparoscopy. The lessons learned have led to the formation of defensive strategies for prevention as well as treatment plans to deal with complications once they occur.

Complications from laparoscopic procedures may arise from almost every aspect of the operation, beginning with patient selection and preoperative planning. Once in the operating room, complications may arise from patient positioning, obtaining initial access, trocar placement, the establishment of pneumoperitoneum, dissection, or closure. In this chapter, we review the potential complications that can occur during each of these areas. Strategies aimed at complication prevention, recognition, and treatment are discussed.

PREOPERATIVE PLANNING

Preventing complications begins with careful patient selection and preoperative management. Active infections are treated and any coagulopathies are addressed before laparoscopic surgery is undertaken. Anticoagulant medication is discontinued before surgery. Medical and cardiac clearances are sought when indicated. Patients with significant cardiopulmonary disease may be unable to tolerate pneumoperitoneum and may require use of helium insufflant or conversion to an open procedure. Assessing the level of difficulty and the appropriateness of the laparoscopic approach for a given case is largely dependent on the experience of the surgeon. For example, although a laparoscopic nephrectomy can be successfully performed on an individual with a 15-cm tumor, inexperienced surgeons may not wish to attempt such cases.

Informed Consent and Patient Expectations

Obtaining and documenting appropriate informed consent are critical before initiating any surgical procedure and has particular relevance should a complication arise. Although no patient wishes to believe that he or she will have a suboptimal outcome, it is important to review the potential complications of a given laparoscopic procedure to ensure that the patient has reasonable expectations. Many patients mistakenly equate the smaller scars and diminished pain of laparoscopy with lesser risk. A significant learning curve exists for many laparoscopic procedures, and the surgeon's personal experience and complication rates should be discussed. Although laparoscopic renal surgery is less morbid than comparable open approaches, many patients assume that their postoperative course will be similar to that seen with other commonly performed laparoscopic procedures, such as tubal ligation and cholecystectomy. The surgeon must explain that laparoscopic renal surgery is associated with more postoperative discomfort than some of the more commonly performed laparoscopic procedures. Patients must always be made aware that conversion to an open procedure may be necessary to safely complete the proposed operation. Discussion of this point takes psychological pressure off the surgeon to try to complete the operation laparoscopically if circumstances may be more optimally handled by an open procedure.

Radiographic Planning

Preoperative imaging is essential to aid in surgical planning, access, and dissection and to help avoid complications. Computed tomography with three-dimensional reconstruction may be of value in assessing the anatomy of the renal vasculature, collecting system, and parenchyma during partial nephrectomy and living donor nephrectomy. Imaging studies that answer all relevant anatomic questions should be obtained and readily available in the operative suite. Once the patient is on the operative table, inspection of the surface anatomy relative to the radiographs will aid in optimal port placement.

Anesthetic Concerns

The physiologic impact of a moderate (10–20 mm Hg) CO_2 pneumoperitoneum is manifold, with significant effects on the

patient's cardiovascular and pulmonary systems. It is important that both the surgeon and anesthetist are aware of the potential physiologic complications of laparoscopy and maintain open lines of communication throughout the procedure. Continuous monitoring—electrocardiography, pulse oximetry, capnography, and blood pressure—is recommended.

The use of an orogastric tube and avoidance of nitrous oxide is important to limit bowel distention. The literature regarding the impact of nitrous oxide on bowel distention has been equivocal; some studies have demonstrated significant effects,[1] while others have not.[2,3] However, many of these reports included small numbers of patients undergoing shorter procedures, such as laparoscopic cholecystectomy. More recent, larger studies with longer operative times comparable to urologic procedures have demonstrated this anesthetic agent can result in troublesome bowel distention.[4]

Compared with traditional open renal surgery, the insensible losses and third spacing incurred during laparoscopic procedures are greatly diminished. Therefore, fluid replacement should be limited except in the case of donor nephrectomy. Moreover, pneumoperitoneum produces an oliguric state secondary to diminished renal cortical blood flow and renal vein compression.[5,6] The surgeon must, therefore, communicate with the anesthesia staff to prevent overly aggressive fluid replacement based on an attempt to maintain urine output. Lack of attention to this point can result in postoperative fluid overload, especially in the elderly.

Obesity

Obesity has reached epidemic proportions in the United States. Accordingly, questions regarding the safety of laparoscopic surgery for obese patients are of particular interest. Obesity has been considered a risk factor for poor outcomes and complications after surgery, including laparoscopic procedures. Much of the risk associated with obesity is secondary to associated comorbidities, poor wound healing, and a propensity to infectious complications. However, technical challenges specific to obese patients exist, including the maintenance of sufficient insufflation pressures, trocar insertion, and obtaining adequate visualization secondary to limited exposure. As a result, obesity has been considered by some to be a relative contraindication to laparoscopy, supported by early reports that documented an increased rate of complications and of conversion to an open procedure.[7,8]

Subsequently, however, multiple authors have documented that with experience and minor technical adjustments, laparoscopy can be performed safely in obese patients without increased risk. In several reports, obese patients undergoing laparoscopic radical or donor nephrectomy experienced similar complication rates compared with nonobese patients.[9–11] Similarly, laparoscopic adrenalectomy and partial nephrectomy have been demonstrated to be safe in obese patients.[12,13]

Several technical considerations are important to avoid complications when performing laparoscopy on obese patients. Cutaneous anatomic landmarks (e.g., the umbilicus) shift disproportionately with respect to the midline and internal organs when the obese patient is placed in the modified flank position[9] (Fig. 28–1). Therefore, a compensatory lateral shift in trocar placement is important to minimize obstruction by intra-abdominal contents (Fig. 28–2). In addition, proper patient positioning and padding are critical to avoid neuromuscular complications and rhabdomyolysis.

Of course, each patient's body habitus and disease must be individually evaluated and approached in the context of the surgeon's experience. Although patients weighing more than 400 lb have undergone laparoscopic nephrectomy, inexperienced surgeons should not attempt laparoscopic renal procedures in such circumstances.

Surgical History

Special consideration must be given to patients with a history of prior abdominal surgery to avoid complications during laparoscopy. Prior surgery commonly results in the formation of intra-abdominal adhesions, distorted tissue planes, and bowel tacked to the anterior abdominal wall. This can result in difficult access to the peritoneal cavity with the Veress needle or via the Hasson technique, with concomitant risk of vascular or bowel injury. Prior surgical scars may influence decision making regarding trocar position with subsequent limitations in instrument maneuverability. In addition, laparoscopic lysis of adhesions carries a risk of injury to gastrointestinal, vascular, and other intra-abdominal structures. Indeed, in early reports of laparoscopic procedures, a history of prior abdominal surgery was often cited as a contraindication to laparoscopy.

The impact of prior abdominal surgery on laparoscopic surgical outcomes was studied in a series of 700 patients undergoing laparoscopic urologic surgery at a single institution.[14] A history of prior surgery at the same surgical site was associated with longer operative times and increased hospital stay. However, no differences in the rate of complications, conversion to open procedures, or estimated blood loss were observed. Therefore, consistent with general surgical literature regarding laparoscopic cholecystectomy, prior abdominal surgery does not negatively affect the performance or safety of urologic laparoscopy.

With that being said, special care must be taken when gaining access to the peritoneum in patients with a history of prior surgery, in order to do so safely. The Veress needle must be placed away from existing surgical scars to avoid injury to bowel or vascular structures. In addition, consider using the Hasson technique in patients with an extensive surgical history.

The Approach: Retroperitoneal Versus Transperitoneal

Similar to the retroperitoneal-flank versus transabdominal approach in open renal surgery, the retroperitoneoscopic approach to upper tract urologic surgery is a viable alternative to transperitoneal laparoscopy. Each approach has its own advantages and limitations and potential for unique complications.

Disadvantages of the retroperitoneoscopic approach include a limited working space, difficulty in orientation with a relative lack of anatomic landmarks, and abundant retroperitoneal fat. Advantages include avoidance of the peritoneal cavity in patients with extensive surgical history and the pannus in morbidly obese patients. Some authors argue that the retroperitoneoscopic approach offers direct access to the renal vessels, thereby reducing operative times and time to control of the renal hilum.[15]

In theory, the retroperitoneoscopic approach has a reduced risk of bowel-related complications and offers a quicker return

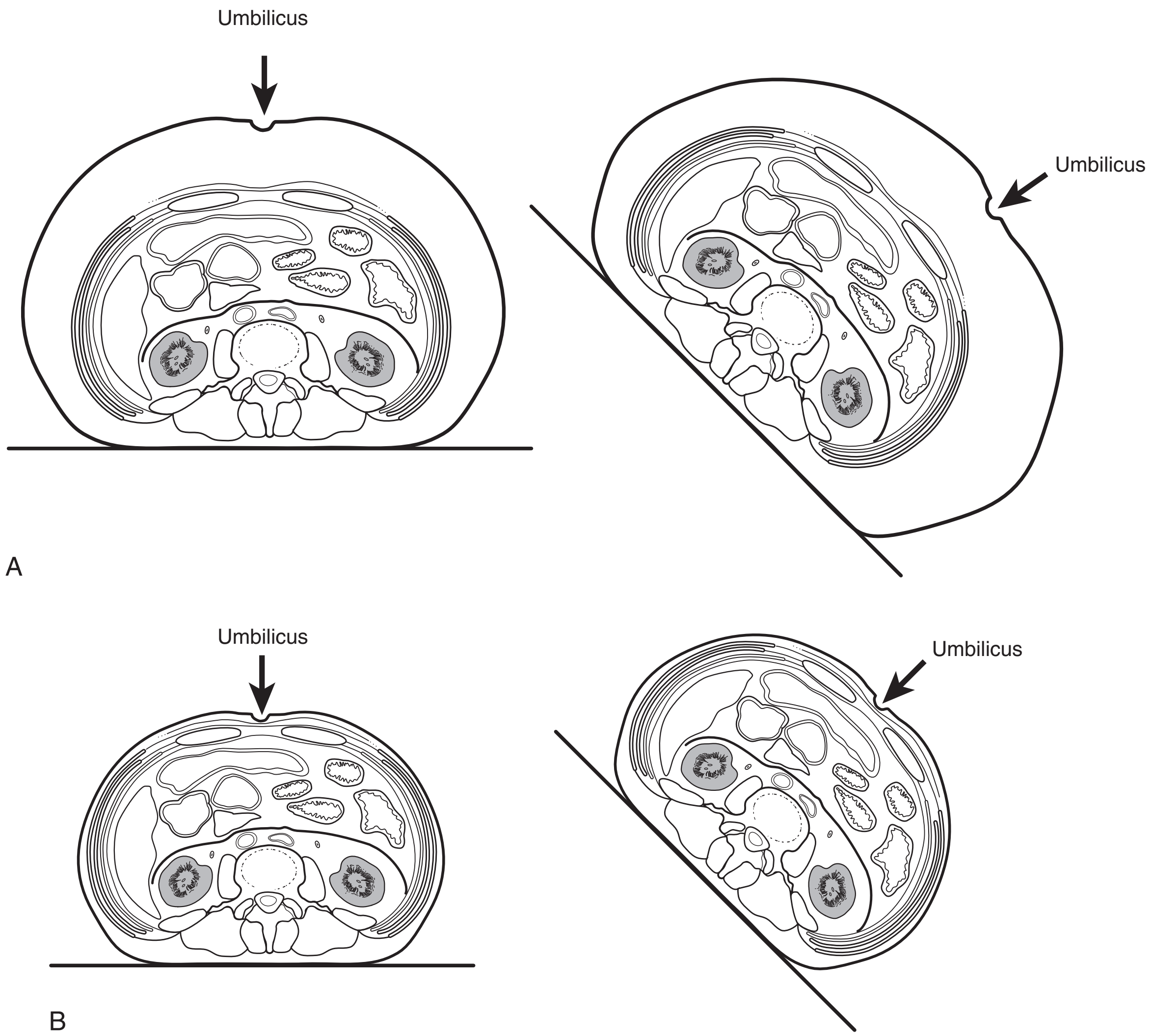

FIGURE 28–1. *A,* When the obese patient is placed in a modified flank position, the pannus and cutaneous anatomic landmarks will shift disproportionately with respect to internal organs (*B*). The *arrow* shows the position of the umbilicus in obese (*A*) and nonobese (*B*) patients.

of bowel activity by avoiding the peritoneal cavity and its contents. Although some reports have noted a quicker return to bowel function and reduced ileus with retroperitoneoscopic nephrectomy,[16] prospective randomized studies have not supported this theory.[17,18]

In experienced hands, the safety of the retroperitoneal approach has been well documented. For example, in an analysis of 404 retroperitoneoscopic procedures, Gill and colleagues[8] reported a 1.7% and 0.25% incidence of intraoperative vascular and bowel complications, respectively.[19] Prospective, randomized studies comparing transabdominal laparoscopic to retroperitoneoscopic nephrectomy have failed to demonstrate a significant difference in the rate of minor or major complications.[18] Of note, injury to the great vessels, including two cases of vena caval transection and one case of aortic transection, has been reported. Because of the relative lack of anatomic landmarks during retroperitoneoscopic surgery, it is important to align the psoas muscle horizontally along the inferior aspect of the field and maintain proper camera orientation.

Although retroperitoneoscopic surgery may, in theory, minimize the risk of injury to intraperitoneal organs, it is important to realize that intraperitoneal viscera are extremely close and protected only by a thin layer of peritoneum. Care must be taken to avoid injury secondary to trocar placement, dissection, retraction, or cautery injury as bowel injuries have occurred.

In the event of vascular injury during retroperitoneoscopic surgery, direct pressure and increased insufflation pressure (15–20 mm Hg) are important early maneuvers to gain hemostatic control and assess the extent of injury. Although bleeding can often be controlled with laparoscopic clips or stapling devices, intracorporeal suturing techniques may be required. As with all inadvertent laparoscopic injuries, a prompt assessment of the severity of the injury and skill set of the operator must be made when contemplating laparoscopic repair versus immediate open conversion.

PATIENT POSITIONING

Attention to patient positioning is of great import during laparoscopy in order to avoid postoperative orthopedic and neuromuscular injuries. Complications include sensory and motor

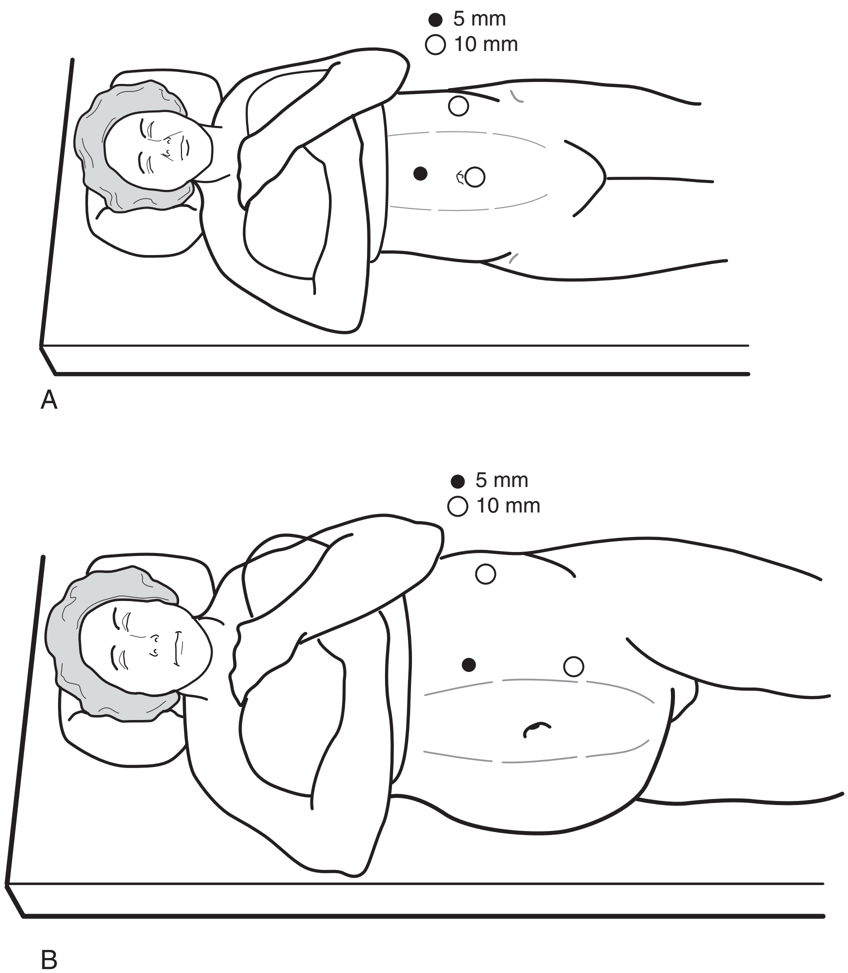

FIGURE 28–2. Landmark changes between *(A)* normal habitus patients and *(B)* obese patients.

deficits, neuralgias, back pain, and rhabdomyolysis. Such injuries are more common after retroperitoneal versus pelvic laparoscopic surgery, with an occurrence of 3.1% reported in the literature.[20] Careful attention to patient positioning is imperative to avoid compression or stretch injuries to the extremities, particularly the brachial plexus. Prevention includes using foam pads at pressure points, maintaining the head in the neutral position, and, when indicated, adding a properly placed axillary/chest roll.

Rhabdomyolysis is a potentially serious complication of laparoscopic surgery. The incidence of clinical rhabdomyolysis after laparoscopic surgery in the flank position has been reported to be as high as 0.4% and is associated with several factors, including male gender, heavier weight, large muscle mass, longer operative times, and the use of a full flank or exaggerated lithotomy position.[20] Management includes intravenous hydration with or without alkalization.

Skin breakdown and pressure sores are also a potential complication secondary to patient positioning and are associated with the flank position and prolonged operative times.[21]

Affix patients to the operating table with wide tape to avoid shifting of position during the operation. Moving the table to its limits before draping the patient is a good test of security. Some surgeons have advocated using a beanbag to steady the patient; however, there have been reports of a compartment syndrome in the flank that was in contact with the bag in thin muscular patients.

TROCAR PLACEMENT

Laparoscopic surgery is predicated on the development of a pneumoperitoneum in order to create an adequate and symmetrical operative space. Initial access to the peritoneal cavity can be obtained via "blind" techniques, including Veress needle access or direct trocar insertion, or under direct vision using the Hasson technique or optical access trocars. Each approach has its own advantages, limitations, and risk of associated complications. In all cases, carefully inspect the abdomen for scars. Place the Veress needle and trocar well away from these areas to prevent injury to bowel or omentum that may be adherent to the anterior abdominal wall.

Veress Needle Access

Closed access using a Veress needle and blind placement of the first trocar can result in significant injury. In large series, the incidence of visceral and vascular injury has each been reported to be approximately 0.1%.[22–24] In addition, incorrect placement can lead to insufflation of potential spaces outside of the peritoneum, which can complicate subsequent attempts at access.

Place the Veress needle away from any previous scars or sites of surgery. Avoid placing the needle too deeply so as not to cause bowel or vascular injury. The needle needs to pivot freely about the skin entry site without resistance. The saline injection test

may be helpful but is not always accurate. Injected saline should flow easily and should not return with aspiration. The negative intra-abdominal pressure should draw fluid placed at the hub of the needle into the peritoneal cavity. Finally, opening pressures should typically be less than 5 mm Hg and will vary with the patient's respirations. Higher pressures may be noted in obese individuals owing to the weight of their pannus. Initial feel of the needle and insufflation pressures are the best barometers of correct needle placement.

High initial pressure or rapidly rising pressure prompts the suspicion of incorrect needle placement. Asymmetric insufflation may imply insufflation of bowel; however, this finding may also be seen in patients with prior surgery in which muscle had been transected or during extraperitoneal insufflation. If bowel insufflation is recognized, it may be necessary to abort the laparoscopic procedure because the dilated bowel can impede adequate visualization. If a Veress needle pierces bowel, remove the needle and carefully inspect the site. If the enterotomy appears limited and no enteric contents are seen, the event may be managed conservatively.

Initial Trocar Placement

Consideration of several technical points can help minimize the potential for injuries with initial trocar placement. A key principle involves minimizing the force needed to introduce the trocar into the abdominal cavity. Something as simple as making too small a skin incision can lead to pitfalls. The incision must be wide enough to allow easy passage of the outer trocar sheath through the subcutaneous tissue (Fig. 28–3). If the opening is made wide enough to permit only the obturator to pass, this can result in catching of the sheath on the skin edge. This can cause the surgeon to exert undue force on the abdominal wall. Conversely, the incision must not be too big, or it may result in leakage of the pneumoperitoneum as well as a suboptimal cosmetic result. A sharp tip must be maintained on reusable trocars so that they can easily cut through the abdominal fascia.

Another technique that can facilitate the closed approach is to increase the pneumoperitoneum during initial trocar placement. The elevated intra-abdominal pressure increases the rigidity of the abdominal wall as trocars are advanced. If significant abdominal wall laxity exists despite an adequate pneumoperitoneum, lifting up on the skin with towel clips can provide countertraction.

Unlike Veress needle injuries, trocar injuries to the bowel require surgical treatment. A small bowel, stomach, or colonic injury in a patient who has undergone mechanical bowel preparation may be repaired laparoscopically. If there is concern regarding the extent of injury, open repair may be indicated.

Hasson Technique

The open Hasson technique for initial trocar placement has been advocated by some as having a lower rate of complications compared with the closed technique. Opponents believe it to be cumbersome, time consuming, and prone to gas leak. Although large studies substantiate the low rate of vascular injuries with this approach, vascular injury has been reported.[25,26] Significant bowel injury has also been reported.[27] In a retrospective review of 6173 laparoscopic procedures, a 0.06% incidence of bowel injury was reported using the open technique.[28]

When using the Hasson method, make the incision under direct vision to avoid injuring abdominal organs. Upon opening the peritoneum, carefully sweep under the peritoneum with an index finger to be certain that bowel is not adjacent to the incision site. Also, when placing stay sutures for the Hasson trocar, be watchful not to incorporate viscus or omentum into the wound (Fig. 28–4).

Optical Trocars

Optical trocars, in which the laparoscope and cannula are inserted together as a unit, have been developed to help minimize injury associated with blind trocar placement. One optical trocar system involves a bladeless trocar that does not require prior pneumoperitoneum. Alternatively, an optical trocar with a recessed knife blade can be used after the creation of pneumoperitoneum with the Veress needle. However, even when trocars are placed under direct vision, injuries inevitably occur; complications using either method have been reported in approximately 0.3% of cases.[29,30]

Direct Trocar Placement

To avoid Veress needle–related complications, some surgeons advocate direct placement of an initial trocar before the establishment of pneumoperitoneum. Keys to safely gaining access in this fashion include sufficient abdominal wall relaxation, an adequate skin incision, and a sharp trocar. Prospective randomized trials comparing closed access versus direct trocar insertion have demonstrated equal, if not superior, safety of the direct trocar technique.[31–33]

Secondary Trocar Placement

Regardless of the technique used to place the initial trocar, always position secondary trocars under direct vision. When possible, place these secondary trocars lateral to the rectus muscle or in the midline to avoid injury to the epigastric artery or one of its branches. Once a skin insertion site is selected, inspect the underlying peritoneal surface to avoid injuring vessels. Transillumination of the abdominal wall can help identify superficial abdominal wall vessels.

PROCEDURE

Insufflation and the Pneumoperitoneum

Incorrect placement of a Veress needle can result in inadvertent insufflation of extraperitoneal spaces with subsequent extravasation of gas along tissue planes. The most common site of incorrect needle placement is the preperitoneal space (Fig. 28–5). Such placement results in an increased distance between the skin and peritoneal cavity, which may necessitate open trocar placement in order to gain access.

Moreover, preperitoneal or retroperitoneal insufflant can pass between diaphragmatic fibers or alongside the great vessels resulting in pneumomediastinum, which, in turn, can lead to pneumopericardium or pneumothorax.[34]

Insufflation of the subcutaneous space can be a result of incorrect placement of the Veress needle or secondary to leakage of gas around trocars. The resultant subcutaneous emphysema

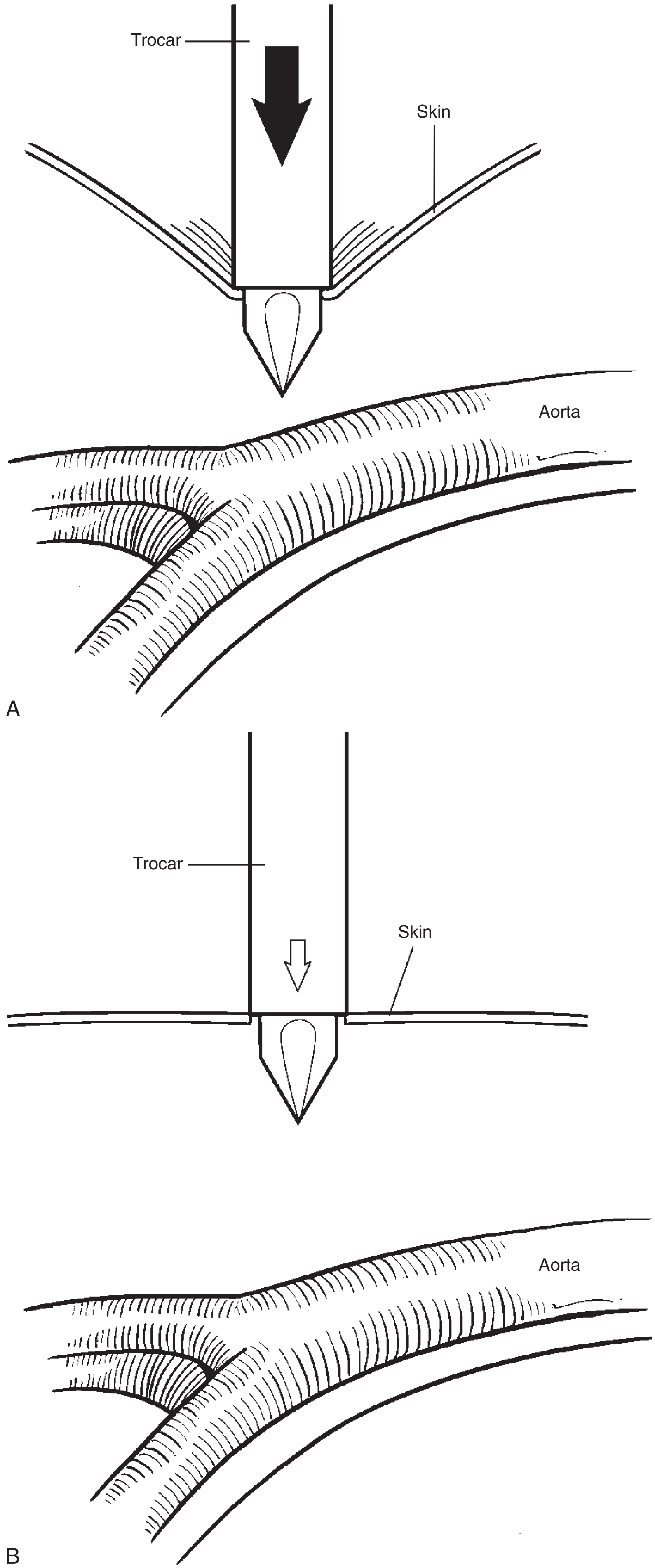

FIGURE 28–3. *A,* The outer sheath of the trocar catches skin if the incision is not wide enough. This requires exertion of excess pressure on the abdominal wall with the potential for injury to underlying organs if the trocar suddenly passes into the abdomen during attempted placement. *B,* In this illustration, the skin incision has been made long enough to allow the edges of the trocar to pass with less pressure applied to the abdomen and less chance for injury to underlying structures.

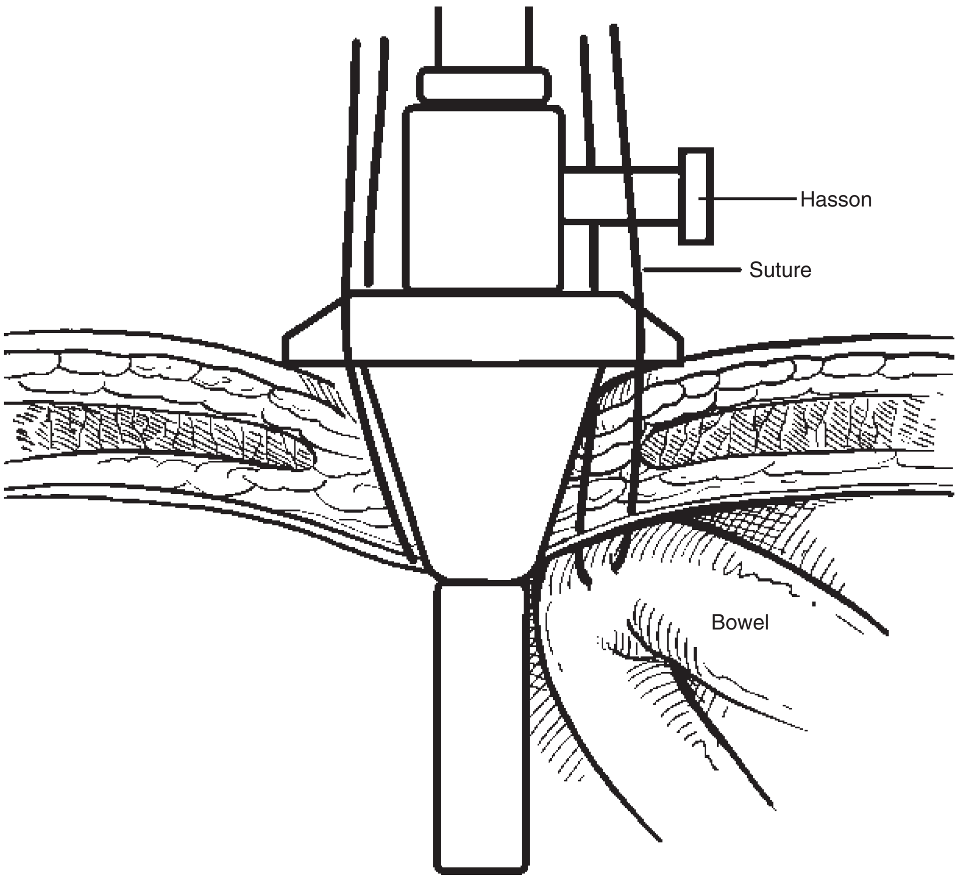

FIGURE 28–4. Using a traditional Hasson trocar placement with suture placement can entrap bowel in the fascial stitch.

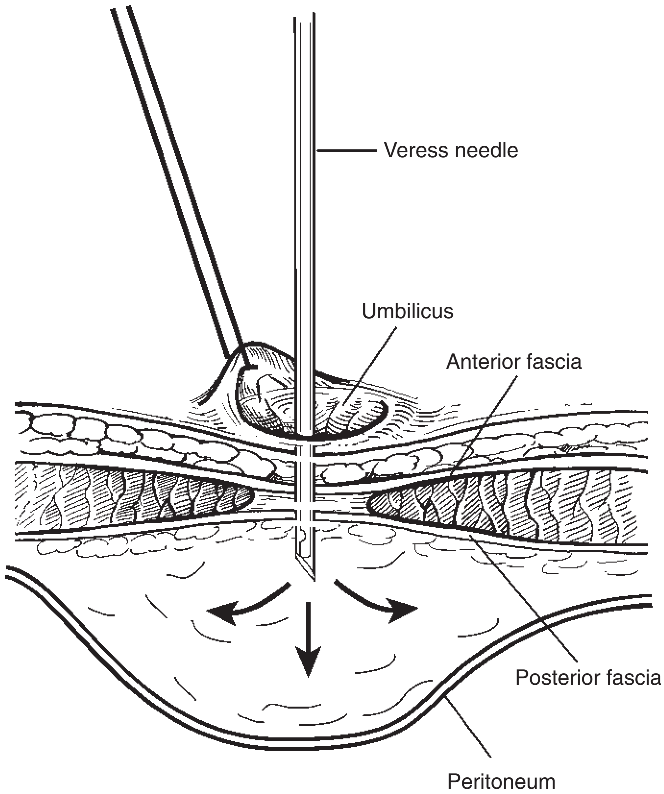

FIGURE 28–5. Insufflation of the preperitoneal space pushes the peritoneum away from the abdominal wall, making subsequent intraperitoneal access troublesome and impairing visualization.

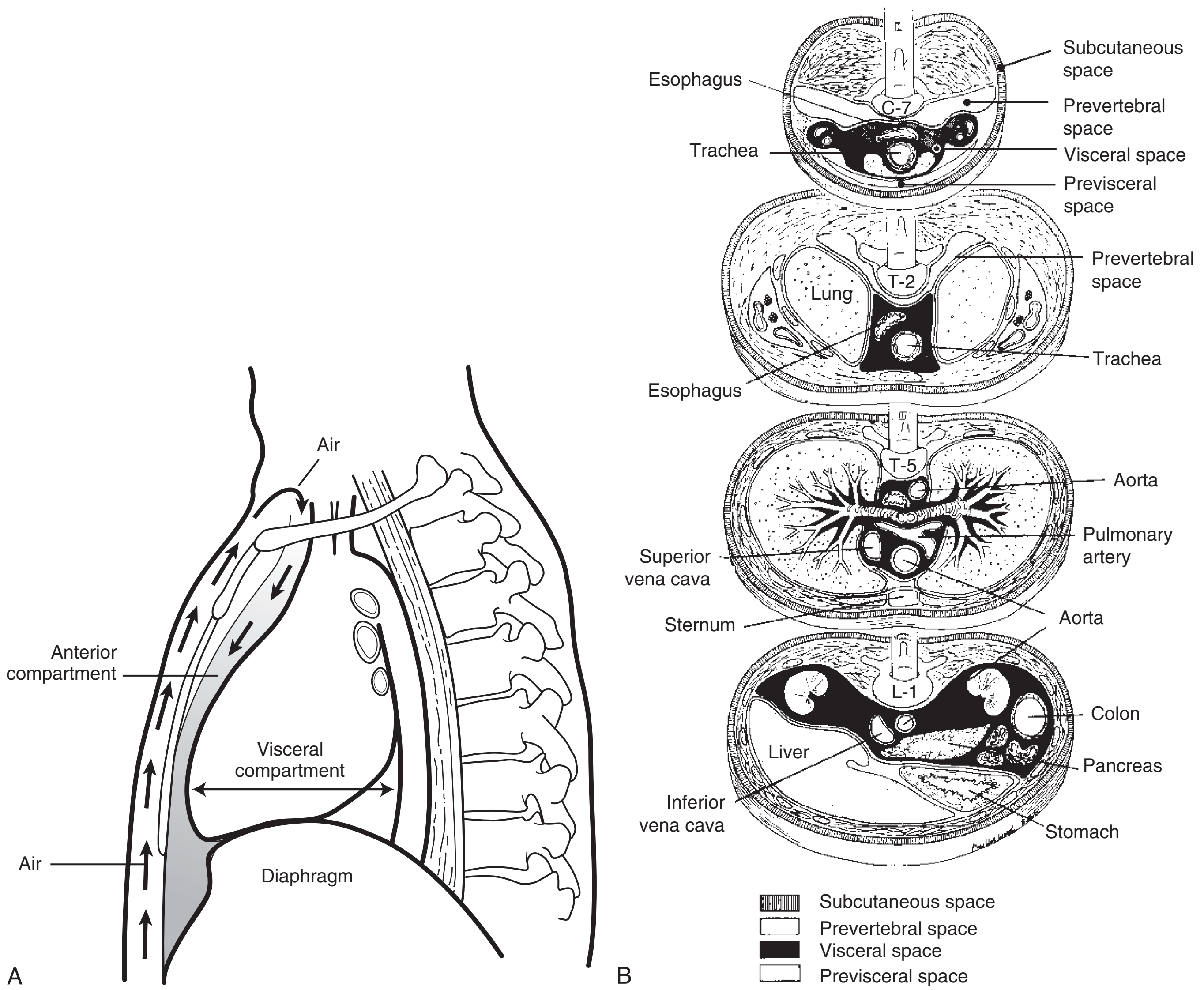

FIGURE 28–6. *A,* Anatomic fascial planes in the neck communicate with the subcutaneous tissue planes allowing for egress of gas into the mediastinum. *B,* Compartments of the mediastinum. The viscera of middle compartment are in continuity with the neck and retroperitoneum.

is usually of no clinical consequence; once the procedure is complete, the gas is absorbed. However, extensive dissection of gas can lead to pneumothorax, pneumomediastinum, and hypercarbia. The risk of development of a pneumomediastinum increases when crepitus is noted extending up to the neck. Due to a continuum of fascial planes existing between the cervical soft tissue and mediastinum, the potential exists for gas to track upward into the neck and down into the mediastinum[35,36] (Fig. 28–6). Subclinical thoracic air collections have been reported in 5.5% of urologic laparoscopic procedures, which can often be managed conservatively due to the high solubility of CO_2.[37,38] However, if symptomatic pneumothorax or pneumomediastinum develops, the pneumoperitoneum should be discontinued and the ectopic gas evacuated.

A pneumothorax can also occur in the absence of subcutaneous emphysema. Insufflant can enter the pleural space through anatomic or congenital defects in the diaphragm. Complications of anesthesia and positive-pressure ventilation, as well as patient conditions such as emphysematous bullae, can also lead to the entry of air into the pleural cavity.[39]

After the pneumoperitoneum is successfully established, the presence of pressurized gas in the abdominal cavity has significant and variegated physiologic consequences that can result in complications. The cumulative response of the cardiovascular system during laparoscopy with CO_2 under moderate pressure (10–20 mm Hg) is generally sufficient for healthy individuals to tolerate pneumoperitoneum. However, patients with significant cardiovascular or pulmonary disease may not compensate sufficiently. In addition, careful attention to insufflation pressure is critical to avoid excessive tension and potential cardiovascular collapse.

Although appropriate ventilatory adjustments are usually sufficient to eliminate the increased CO_2 load that results from laparoscopy, in some patients, CO_2 insufflation can produce

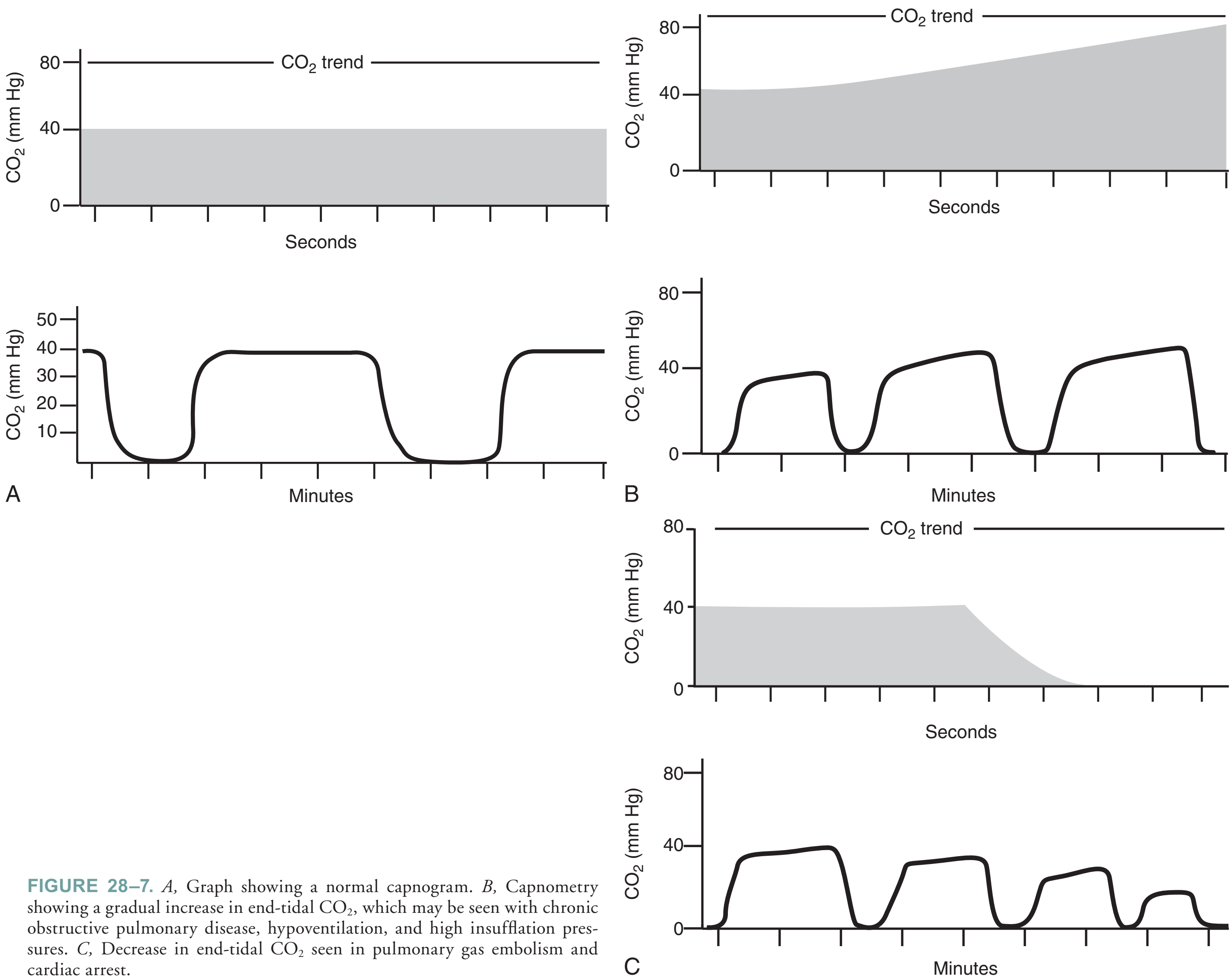

FIGURE 28–7. *A,* Graph showing a normal capnogram. *B,* Capnometry showing a gradual increase in end-tidal CO_2, which may be seen with chronic obstructive pulmonary disease, hypoventilation, and high insufflation pressures. *C,* Decrease in end-tidal CO_2 seen in pulmonary gas embolism and cardiac arrest.

profound hypercapnia. This can be exacerbated by subcutaneous emphysema and excessive intra-abdominal pressures. If severe, hypercapnia and acidosis can have significant depressive cardiac effects. Initial management consists of lowering the intra-abdominal pressure. If the anesthesiologist cannot adequately compensate, helium may be used or the procedure may need to be converted to open surgery.

Insufflation can also produce significant cardiac arrhythmias, including bradycardia, tachycardia, ventricular extrasystoles, atrioventricular dissociation, and nodal rhythms. Hypercapnia, as well as a vagal response to abdominal distention and peritoneal irritation, has been implicated. The use of atropine prior to insufflation may prevent these vagal reactions.[40]

A rare but potentially fatal complication related to the pneumoperitoneum is a gas embolism, which occurs most commonly during the induction of pneumoperitoneum. Although intravasation of gas due to the increased intra-abdominal pressure has been suggested as an etiology, the most common cause is direct placement of a needle or trocar into a vessel or abdominal organ.[41,42] In a meta-analysis of nearly 500,000 laparoscopic procedures with closed access, the incidence of gas emboli was 0.0014%.[43]

Patient survival after gas embolism depends on rapid diagnosis and treatment. The diagnosis can be difficult, and there is often no warning before acute cardiovascular collapse, particularly during insufflation. When the size of the embolus increases, tachycardia, arrhythmias, hypotension, and increased central venous pressure may be noted. Hypoxia, hypercapnia, and cyanosis may also be evident. Electrocardiographic changes can include a right heart strain pattern, and auscultation may reveal the classic "mill wheel" murmur just before the acute event. Also, an acute decrease in measured end-tidal CO_2 measurements is noted as the embolism occludes the pulmonary trunk (Fig. 28–7). When an embolism is suspected, release the pneumoperitoneum and administer 100% oxygen. Place the patient in the left lateral decubitus position with the head down to move the gas away from the pulmonary artery (Fig. 28–8). Institute cardiopulmonary resuscitation, and place a central venous catheter in an attempt to aspirate the gas. Percutaneous or open evacuation of the gas may be indicated.[44–47]

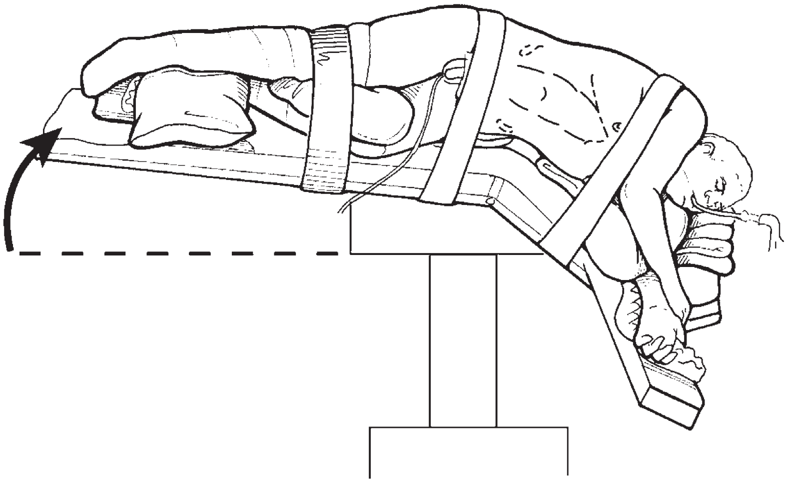

FIGURE 28–8. Position for suspected air embolism: left lateral decubitus and head down.

Vascular Injury

Vascular injuries are among the most common and challenging complications of urologic laparoscopy, occurring in 2.8% of procedures.[48] Vascular injury can be a result of Veress needle and trocar placement or from trauma sustained during dissection. Many of these injuries are minor and are easily managed, whereas others have catastrophic potential. A thorough understanding of vascular anatomy and constant attention to maintaining orientation are critical to avoid vascular complications.

Placement of the Veress needle into vascular structures is a well-recognized complication. Early recognition of such an event is key to minimizing the extent of injury. After introduction of the Veress needle, always perform aspiration; if blood is withdrawn after initial needle placement, remove the needle and make another attempt to gain access. Never torque the needle when blood returns; such manipulation can convert a puncture wound into a laceration. If bleeding appears significant, leave the Veress needle in place and close the stopcock. This step will minimize bleeding and allow the surgeon to track the needle to the exact site of injury.

Trocars are a significant cause of vascular injury and most often involve abdominal wall vessels. These injuries are commonly recognized by the observation of blood dripping from the trocar sleeve or of hematoma forming about the trocar site. Although such bleeding often resolves without intervention, when necessary, several maneuvers are available to control bleeding from abdominal wall vessels. If the bleeding is minor, apply electrocautery under direct vision. This can be performed from the peritoneal surface or through the trocar site while the trocar is slowly backed out. If the bleeding is brisk, pass a Foley catheter down the trocar; then inflate the balloon and put on traction to tamponade the bleeding vessel (Fig. 28–9).

More significant bleeding may require sutures to achieve hemostasis. Pass a figure-of-eight suture using a Carter-Thomason needlepoint fascial closure device (Inlet Medical, Eden Prairie, MN) (Fig. 28–10). If this maneuver is unsuccessful, open exploration of the trocar site may be indicated.

Occasionally, abdominal wall or intra-abdominal vessel injury is not noted until the postoperative period. Hypotension or tachycardia associated with a decreasing hematocrit raises the suspicion of ongoing hemorrhage. Significant pain about a trocar site, ecchymosis, and a palpable paramedian mass are signs of a hematoma within the rectus sheath. Correction of any underlying coagulopathy is the initial step; continued hemodynamic instability, however, would warrant exploration for persistent bleeding.

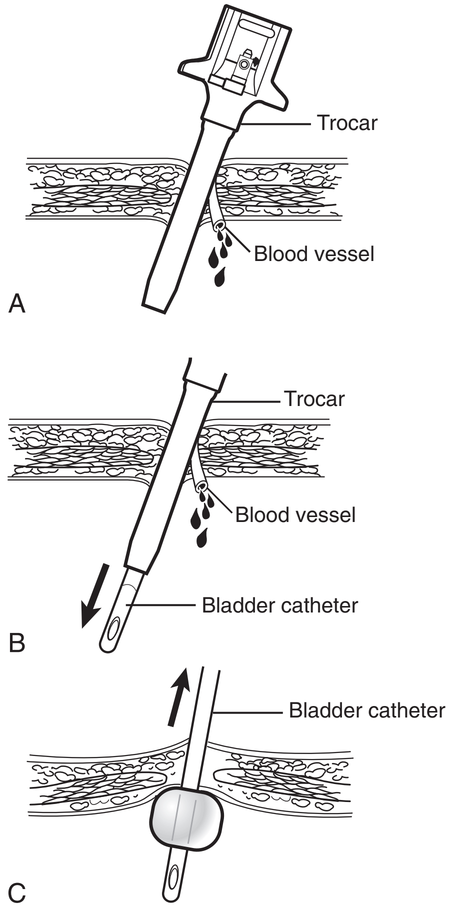

FIGURE 28–9. *A,* Placement of the trocar through an abdominal wall vessel can cause persistent bleeding that is not stopped with trocar placement. *B,* A bladder catheter is inserted through the trocar site. *C,* The catheter balloon is inflated and put on tension to tamponade the bleeding vessel.

Trocar placement can also result in major vessel injury and is related to the use of excessive force to advance the trocar.

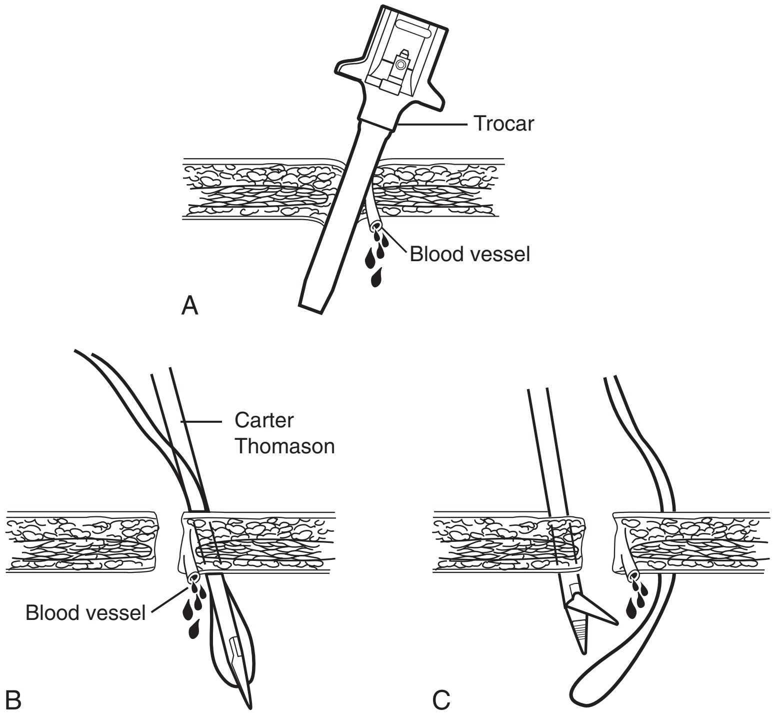

FIGURE 28–10. *A,* Persistent bleeding from trocar site. *B,* A figure-of-eight suture can be passed with the Carter-Thomason needlepoint fascial closure device (Inlet Medical, Eden Prairie, MN). *C,* The suture pass is effective in ligating a bleeding trocar site vessel.

This is a particular risk with extremely thin patients; the great vessels can be deceptively close to the abdominal wall. Remember that even major bleeding may not be immediately recognized if the injury is confined to the retroperitoneum. When a major trocar injury is suspected, perform immediate laparotomy. Leave the trocar in place to help tamponade the vessel and aid in localizing the site of injury. Do not move the trocar in order to prevent converting a puncture into a larger tear. Attempt to control bleeding proximally and distally. Moreover, it is important to mobilize the vessel and inspect the back wall for a possible through-and-through injury.

A mesenteric hematoma may occur as a consequence of trocar placement or dissection. If identified, closely monitor the hematoma. Evidence of expansion or compromise to bowel circulation warrants exploration.

Vascular injury can also occur during dissection. Each injury is individual and requires unique definitive treatment; however, general recommendations can be made. Most vascular injuries related to the upper urinary tract involve branches of the renal vein or vena cava, although arterial injuries are possible. Take care to avoid placing undue tension on veins during dissection of venous branches. It is important to realize that an instrument passed through a trocar site acts as a lever. As such, significant torque can be generated at the tip of a given instrument (Fig. 28–11). Be cautious, therefore, when positioning retractors on viscera or the mesentery. Follow basic tenets of open surgery, such as the avoidance of past-pointing the tip of the scissors when cutting.

Endovascular gastrointestinal anastomosis (GIA) stapling devices are routinely used during laparoscopic nephrectomy for division of the renal vein or artery. Malfunction of such devices can cause significant vascular complications and has been reported to occur in 1.7% of cases.[49] Stapler malfunction is often secondary to preventable causes, not the primary device failure. Ensuring that no surgical clips or unintended tissue or vessels are within the stapler jaws is critical to help prevent stapler-related complications (Fig. 28–12).

When brisk bleeding from a vascular injury is noted, use the irrigator-aspirator to help identify the source and aid compression. Increase intra-abdominal pressure to 20 to 25 mm Hg to help with tamponade as well as to compensate for aspiration of gas. Also, use a Foley catheter preloaded with a catheter guide to occlude the bleeding site (Fig. 28–13).

The approach to management of a vascular injury depends on its location and severity. The surgeon must use personal judgment to rapidly determine whether the equipment or skills are available to repair a given injury laparoscopically. Random or blind placement of clips is often ineffective, clutters the operative field, and risks inadvertent narrowing or occlusion of a vital vessel. Dissection of surrounding structures often clarifies the site of bleeding.

Small venous bleeders can often be treated with electrocautery or clips. If a small tear or avulsion occurs in the renal vein or vena cava, make an attempt to grasp both ends of the tear with an atraumatic grasper. Alternatively, open a gauze pad, pass it through a trocar site, and use it to place pressure on the venotomy for 5 minutes.

Moderate bleeding may require suturing for repair. Place a freehand stitch with a pretied knot across the opening in a vessel (Fig. 28–14). Alternatively, use a Lapra-Ty absorbable clip (Ethicon Endo-Surgery, Cincinnati, OH) as a preformed knot (Fig. 28–15). Once the suture is passed, use another Lapra-Ty clip to secure the stitch, or use an automated suturing device to place a suture. With experience, arteriotomies can also be closed. However, when suturing, take care to avoid inadvertent narrowing or occlusion of the vessel. Compromise of major abdominal organs and the entire small bowel has occurred.

Occasionally, significant bleeding that cannot be controlled laparoscopically is encountered. In these instances, attempt to place the tip of an instrument on the area of bleeding as a

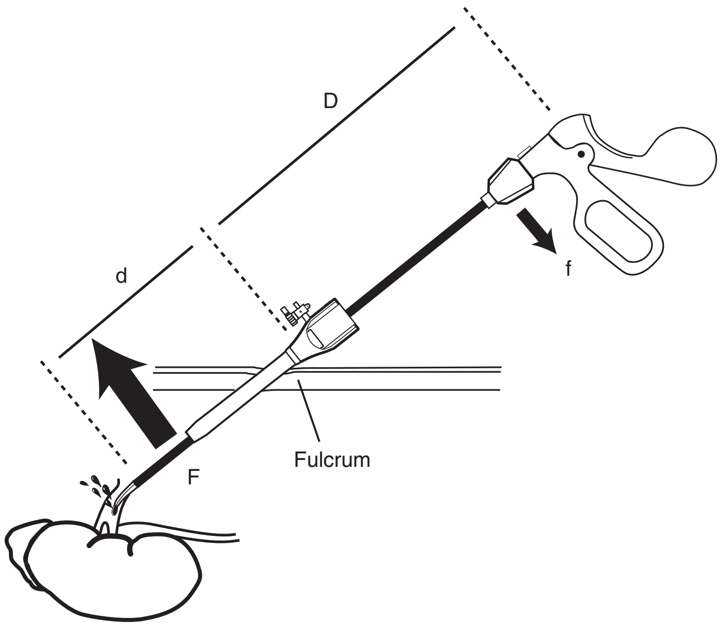

FIGURE 28–11. When an instrument enters the abdominal wall, the fixed skin site creates a lever through which force exerted on the skin can multiply. On the basis of the formula $F/f = D/d$, when $D > d$ the force at F can be much greater than the force at f, and can result in injury.

marker. Perform immediate laparotomy in a location that will permit optimal visualization for control of the bleeding.

Gastrointestinal Injury

Injury to the stomach, intestine, gallbladder, liver, spleen, pancreas, and mesentery have been reported during laparoscopic procedures. Unfortunately, intestinal injury is often unrecognized intraoperatively, can have an atypical clinical presentation, and represents a potentially fatal complication. The incidence of bowel injury during laparoscopic procedures ranges from 0.25% to 2.5% and is usually secondary to needle or trocar insertion, or electrocautery.[50]

Gastric perforation is usually a result of trocar perforation of a distended stomach owing to esophageal intubation or mask ventilation. Thus, it is important to place an orogastric tube before access.

Aspiration of succus or feces may occur when bowel is penetrated during access. A Veress needle injury may be managed conservatively as long as no leakage of enteric content is noted. When a trocar injury to bowel is noted, leave the trocar in place to help identify the site of injury. Small perforations may be approached laparoscopically, but extensive injuries in unprepared bowel may require open repair and diversion.

A thermal injury to the bowel represents a serious complication because patients do not show symptoms of such injuries for several days postoperatively. Failure to recognize such an injury can result in significant morbidity. Prevention of burns depends on the careful use of electrocautery. Before using electrocautery, inspect all instruments to be certain that insulation is intact. Moreover, when current is applied, the entire tip of the instrument must be kept within the visual field. Finally, be certain that the tissue to be cauterized is isolated from surrounding tissue to prevent inadvertent injury secondary to thermal conduction through tissue.

When detected intraoperatively, repair all bowel injuries.[51] Intestinal burns may be more extensive than visually apparent. Therefore, perform a wide resection to ensure removal of all injured tissue.

Unfortunately, bowel injuries are often not recognized at the time of initial laparoscopic surgery.[52] The patient often presents 2 to 7 days postoperatively with a persistent ileus and mild distention, vague abdominal discomfort, notable trocar site pain, nausea, or diarrhea. Peritoneal signs are commonly absent. Many patients have only a low-grade fever, and leukocytosis may not be present; in fact, many patients exhibit leukopenia. A complete blood count with manual differential usually demonstrates a left shift. A plain abdominal film may reveal an ileus pattern and free air; however, this latter finding is not helpful because the insufflant from the pneumoperitoneum may be visible for several days following laparoscopy. If the symptoms of bowel injury do not rapidly respond to conservative measures, undertake radiographic studies and surgical exploration as indicated.

Splenic and liver lacerations can be managed conservatively. Define the extent of the injury and pack the area with surgical cellulose (Surgicel, Johnson & Johnson, Arlington, TX) or absorbable gelatin sponge (Gelfoam, Upjohn, Kalamazoo, MI). The argon beam coagulator is also invaluable in achieving hemostasis (Fig. 28–16).

The tail of the pancreas can be injured during left radical nephrectomy or adrenalectomy. If this injury is recognized intraoperatively, repair and drain it. Use the GIA stapler to excise the tail of the pancreas, if desired. If such an event is recognized in the postoperative period, place a drain, and follow conservative management.

Urinary Tract Injury

Injuries to the bladder and urethra have been reported for laparoscopic surgery, primarily during gynecologic procedures. It is important to place a Foley catheter before gaining access in order to decompress the bladder. The bladder can be penetrated by the Veress needle or trocar. Such an event manifests as hematuria or gas inflating the Foley bag (Fig. 28–17).

Veress needle injuries to the urinary tract can be managed conservatively, but trocar or dissection injuries may require repair and catheter drainage. If a bladder injury is suspected,

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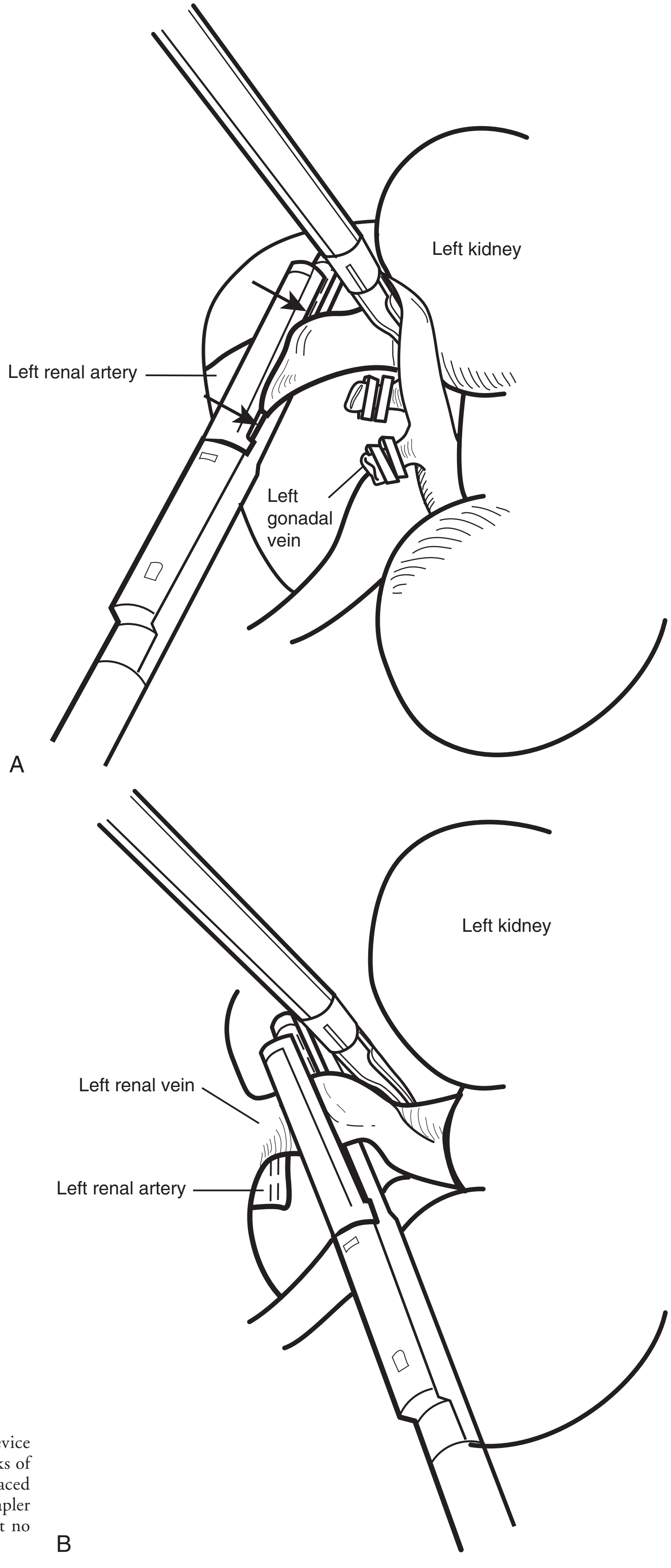

FIGURE 28–12. *A,* Correct placement of an endovascular GIA device on the renal artery. The intended artery is positioned inside the marks of the stapler jaws. Care must be taken to avoid clips if they have been placed on the renal vein branches. *B,* Placement of the endovascular GIA stapler on the renal vein ensures that it is not bunched in the jaws and that no clips are in the jaws.

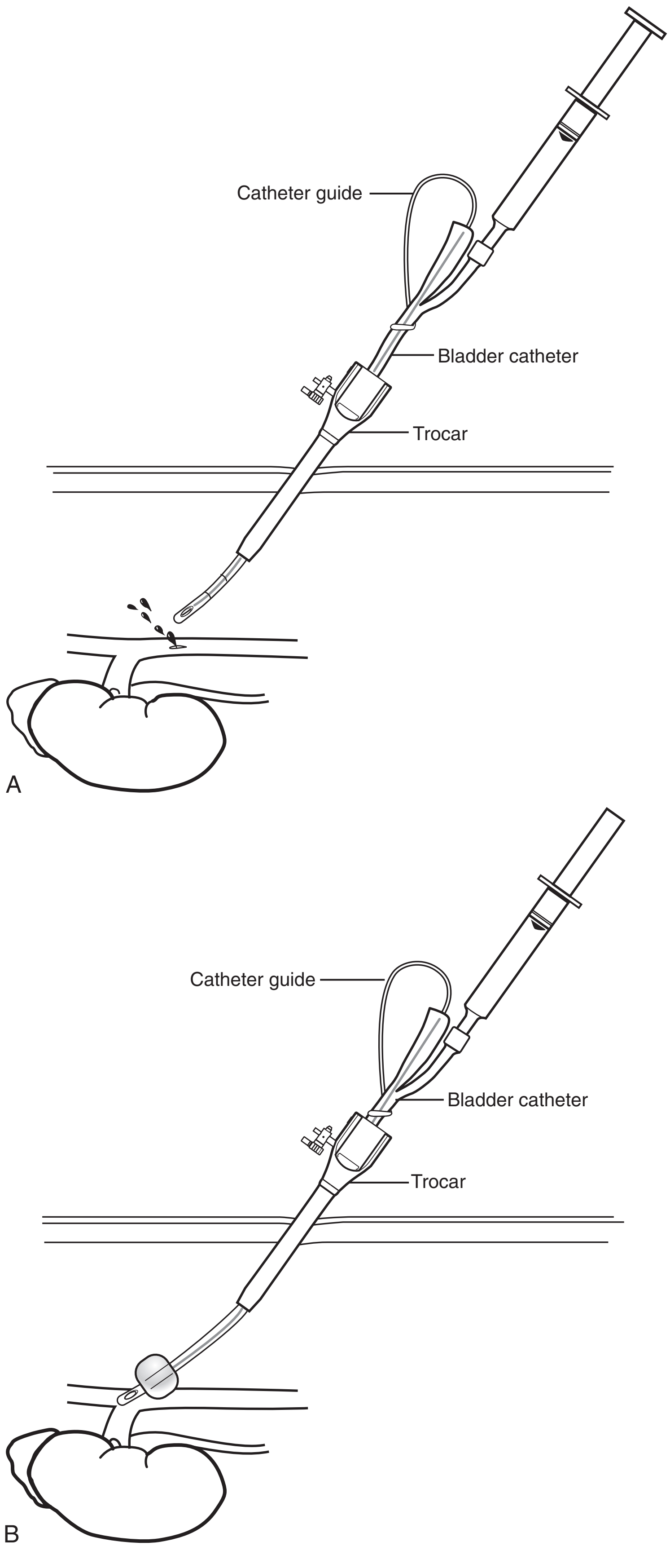

FIGURE 28–13. A bladder catheter with a catheter guide can be used to occlude major vascular bleeding. *A,* A catheter and guide are passed through the trocar to the site of bleeding. *B,* The balloon is inflated with 5 to 15 mL of water and pressure is placed on the bleeding site.

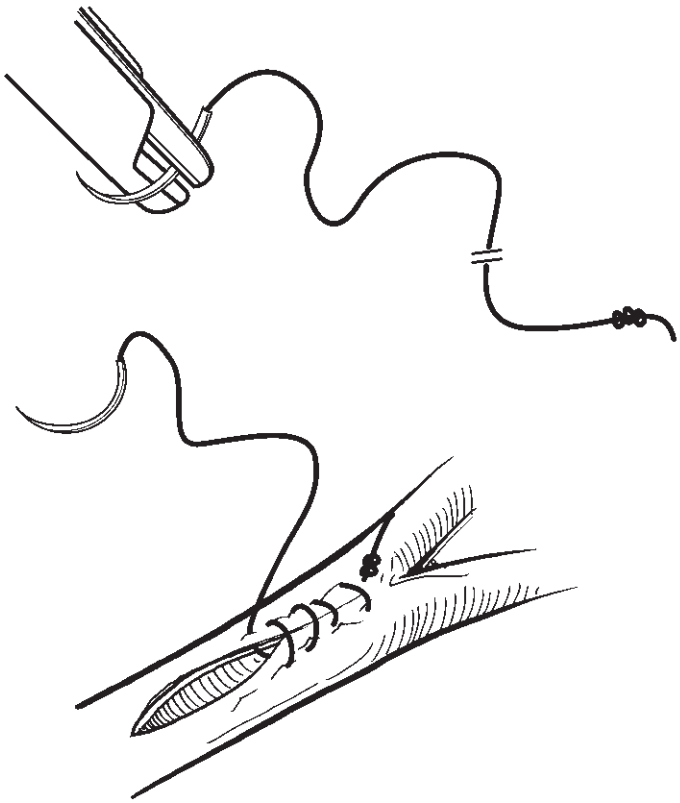

FIGURE 28–14. A knot is placed in the end of a suture cut to an appropriate working length, which is then passed through a trocar and used to rapidly close the defect.

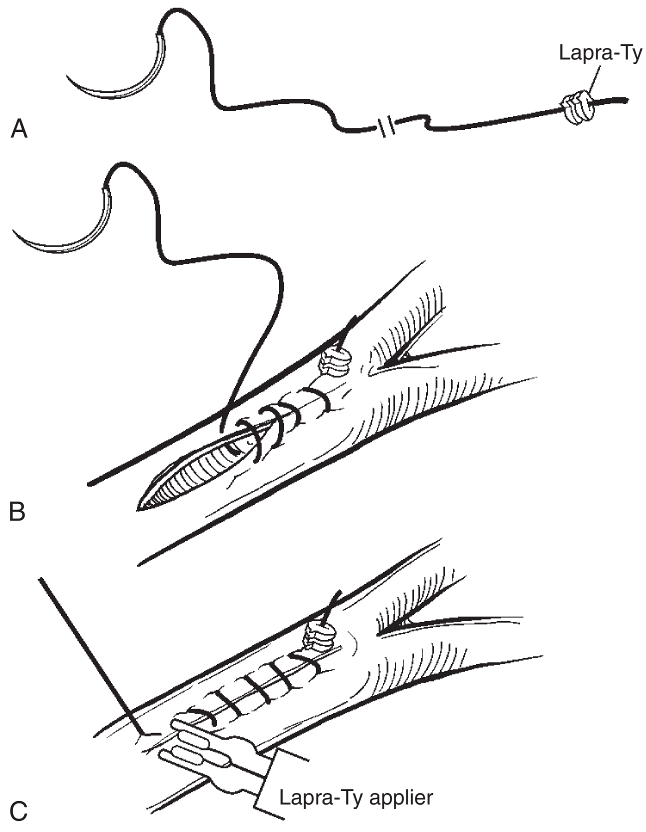

FIGURE 28–15. *A,* A length of suture approximately 8 to 10 cm is cut and a Lapra-Ty absorbable clip (Ethicon Endo-Surgery, Inc, Cincinnati, OH) is placed on the end of the suture. *B,* The suture is passed to close the defect and then upward tension helps control the bleeding. *C,* The suture is complete and a Lapra-Ty clip is placed on the opposite end to maintain tension and hemostasis.

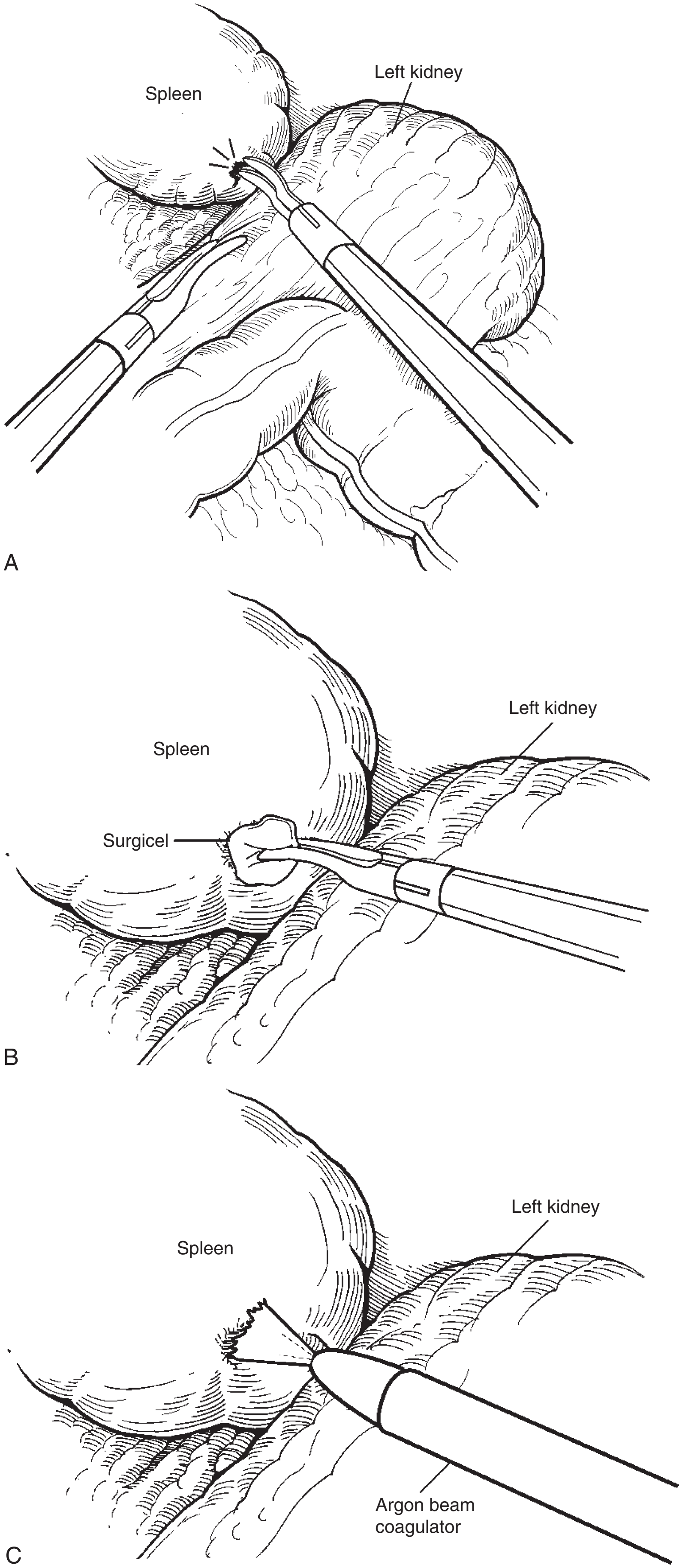

FIGURE 28–16. *A,* Scissors injury to the spleen during nephrectomy. *B,* Surgicel (Johnson and Johnson, Inc, Arlington, TX) is placed on the bleeding site and pressure is applied. *C,* An argon beam coagulator can also be used to achieve hemostasis.

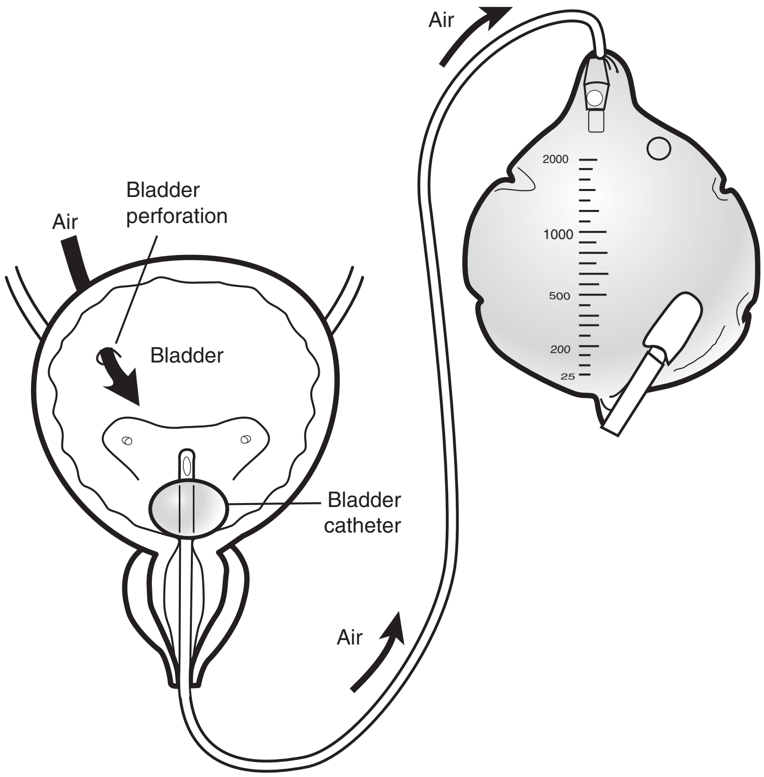

FIGURE 28–17. Bladder injury can allow intraperitoneal gas or blood to escape into the bladder catheter.

instill methylene blue or indigo carmine dye to help identify the site of injury, if desired.

Ureteral injuries usually manifest 1 to 5 days postoperatively. Leakage of urine can result in a urinoma, which causes localized pain, or can extravasate into the abdomen, resulting in peritoneal signs (Fig. 28–18). If such an injury is recognized intraoperatively, undertake endoscopic repair with stenting. Postoperative diagnosis may mandate stent placement, percutaneous drainage, and possible laparoscopic or open repair.

PLEURAL AND DIAPHRAGMATIC INJURY

Laparoscopic renal surgery carries a small but recognized risk of injury to the diaphragm and pleura during dissection or trocar placement, occurring in 0.6% of cases.[53] Diaphragmatic injury can occur during dissection of the upper pole of the kidney or adrenal gland or when mobilizing the liver or spleen (Fig. 28–19). Also, trocars placed above the ribs can violate the pleura and injure the lung. Serious sequelae may result, becoming evident when the patient shows signs of a tension pneumothorax or pneumomediastinum.

Pay careful attention to the diaphragm at all times, especially with renal lesions close to the diaphragm, as well as when mobilizing the liver, spleen, or colon. Injury to the diaphragm or pleura may be recognized directly or suspected when the diaphragm is seen billowing into the surgical field, known classically as the "floppy diaphragm sign." Active communication with the anesthesiology team is critical because decreased oxygen saturation, increased airway pressures, diminished breath sounds, CO_2 retention, and hemodynamic instability are often key in making the diagnosis of pleural injury.

Once pleural injury is recognized, management depends on the stability of the patient. In the unstable patient, immediate release of the pneumoperitoneum and possible needle decompression of tension pneumothorax, or tube thoracostomy, is indicated. In the clinically stable patient, management may involve completion of the nephrectomy with a reduced pneumoperitoneum (10 mg Hg) and close hemodynamic monitoring. This will allow for better visualization of the injury with the specimen out of the field of view. After laparoscopic inspection of the pleural cavity to rule out direct pulmonary injury, perform closure of the diaphragmatic injury and pleurotomy with standard laparoscopic suturing or endoscopic suturing devices. Before securing the stitches, remove residual air from the pleural cavity using a suction device or by placing a 6-French central line into the sixth intercostal space.[53,54] Postoperative chest roentgenogram is necessary to rule out residual pneumothorax.

Partial Nephrectomy

Laparoscopic partial nephrectomy (LPN) is a technically challenging procedure, requiring both extirpative and reconstructive techniques. Moreover, as experienced surgeons tackle larger, more centrally located tumors, the risk of complications, including hemorrhage and urinary leak, is inevitably increased.

Preoperative planning is of particular import to avoid complications during LPN. Spiral computerized tomography can be helpful to define vascular anatomy, tumor location, and proximity to the collecting system and vessels.

The overall complication rate of LPN varies widely in the reported literature. In large contemporary series, the overall complication rate ranges from 19.7% to 33%.[55–58] Hemorrhagic

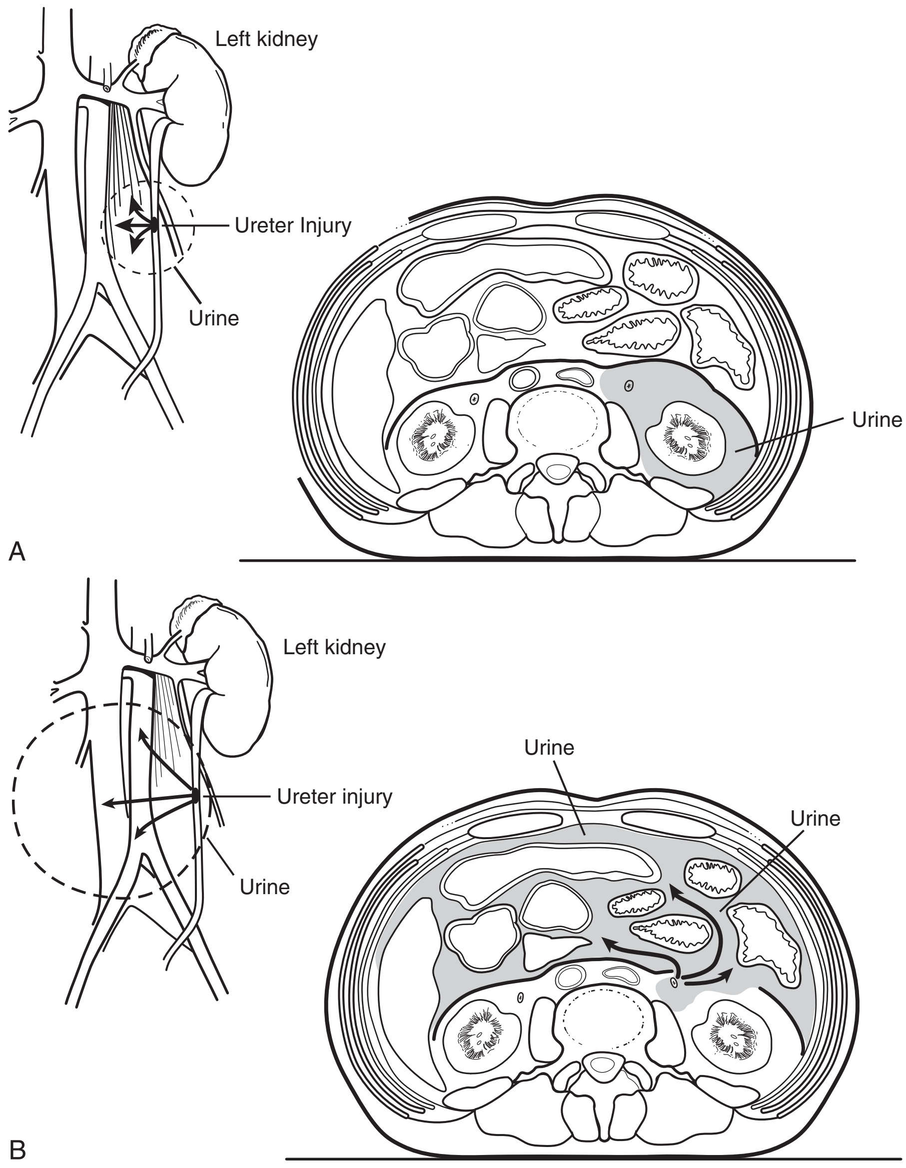

FIGURE 28–18. *A,* Ureteral injury can result in the development of a large retroperitoneal urinoma. *B,* If the peritoneum is not intact, peritonitis can result from seepage of urine and subsequent bowel irritation.

complications can be classified as intraoperative (3.5%–8%), postoperative (1.8%–2%), or delayed (4%).[55,56,58] Hemorrhage associated with LPN can occur during tumor resection due to inadequate hilar clamping or on revascularization secondary to insufficient hemostatic control of the resection bed.[55] Successful identification of supernumerary renal arteries and correct placement of laparoscopic bulldog or Satinsky clamps are critical to ensure hilar control. Although performing LPN without hilar clamping has been reported, it is associated with increased blood loss and limits the clear visualization of renal parenchyma necessary for identifying the renal mass and ensuring surgical margins.[59] Proficient intracorporeal suturing skills are prerequisite for control of parenchymal bleeding and renorrhaphy. Bioadhesives and sealants are useful adjuncts and may reduce hemorrhagic complications during LPN.[60]

Urinary leakage is a well-recognized complication after nephron-sparing surgery. In open series, urinary leak is a common postoperative complication, seen in 1.4% to 17.4% of patients.[61,62] In LPN series, urinary leak ranges from 1.4% to 10%.[55–58] Intraoperative identification of collecting system entry and suture repair of the collecting system may avoid leakage.

In an attempt to reduce urinary fistula formation, some surgeons advocate the placement of an ipsilateral ureteral catheter before nephron-sparing surgery, allowing for retrograde dye injection as an aid to identify entry into the collecting system.[63] However, the use of this approach is controversial, and some authors have reported that ureteral stent placement does not reduce the incidence of early or delayed urinary leaks.[64] Tumor location and size, as well as the experience of the surgeon, should guide the decision of whether to perform retrograde injection of dye during LPN. It must be noted, however, that even with visualization and repair of collecting system entry, urinary leakage can still occur.

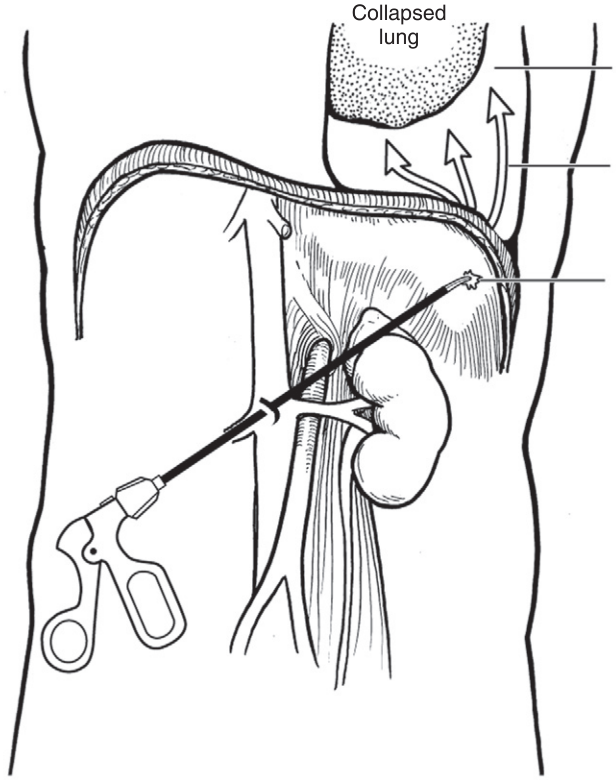

FIGURE 28–19. Injury to the diaphragm can occur during aggressive lateral dissection of the upper pole of the kidney, adrenal gland, or spleen. This injury is usually immediately apparent as the patient will rapidly show signs of increased peak airway pressures, difficulty with ventilation, and, if not corrected, tension pneumothorax.

Coagulation necrosis secondary to excessive electrocautery may contribute to urinary leakage.[65] Therefore, after the use of monopolar electrocautery to outline the circumferential margin of resection, many authors advocate the use of "cold" laparoscopic scissors to perform the resection in attempt to reduce coagulation necrosis and the risk of urinary leak.[64]

Operative treatment for urinary fistula is rarely needed following LPN. Resolution can be expected with conservative management involving the use of prolonged suction drainage. Ureteral stent placement or percutaneous nephrostomy drainage is rarely needed.

Herniation

Port site hernias are generally uncommon, with an incidence of less than 0.1%.[66] Because hernias are more likely to occur with larger trocars, attempt to close them when using ports greater than 10 mm placed anterior to the posterior axillary line. Herniation of bowel into the preperitoneal space (through a peritoneal defect with intact fascia) can occur. Therefore, attempt to close the peritoneum as well as the fascia. Incisional hernias at hand-port sites following hand-assisted laparoscopy have also been reported with an incidence of 1.9%.[67] Take care when using a balloon device to create a working space in the retroperitoneum. If the balloon is inadvertently inflated within the fascia of the abdominal wall, a large defect may be created, resulting in hernia formation. Close all holes in mesentery to avoid a mesenteric hernia.

Laparoscopic Exit

After successful completion of the laparoscopic dissection, it is crucial to maintain vigilance to avoid postoperative problems. It is easy to let down one's guard after the goal of the surgery has been reached following hours of intense concentration. Several set maneuvers must be followed to minimize postoperative pain and the possibility of morbidity.

1. Undertake a thorough examination of the operative field and any ligated vessels to ensure hemostasis. The pneumoperitoneum may have been sufficient to tamponade venous bleeding; therefore, the intra-abdominal pressure should be lowered for 5 minutes, followed by a second inspection. If seepage of blood is noted, patience is crucial in order to locate small bleeding sites. Use electrocautery, suture, or clips as indicated.
2. Once comfortable that hemostasis is complete, survey the bowel and other intra-abdominal structures for injury. Inspect the abdominal cavity for any enteric content emanating from an unrecognized injury. Also, attempt to remove any clots from the abdomen to minimize the risk of postoperative adhesion formation.
3. Perform trocar removal and closure under direct vision. Trocars may tamponade bleeding caused by injury to abdominal wall vessels. Carefully inspect the internal abdominal wall to assess for bleeding or a hematoma after removal of the trocars. If bleeding is noted, perform cautery of the tract or placement of a figure-of-eight suture under direct vision, as needed. If bleeding is significant, place a Foley catheter through the site, inflate it with 20 mL of water, and place it on traction while considering the optimal method of control. A cutdown with open surgical repair may be indicated.
4. In adults, close 10-mm trocar sites anterior to the posterior axillary line to avoid hernia formation. In children, close all 5-mm sites. Close trocar sites under direct vision to minimize the potential for inadvertent bowel injury.

5. Attempt to evacuate all the CO_2 from the abdomen before removal of the last trocar. CO_2 can act as a diaphragmatic irritant, resulting in postoperative back, shoulder, or chest pain. Open the stopcock on the last remaining port with the laparoscope inside. Use the laparoscope to aim the trocar at anterior pockets of gas. The anesthesiologist manually ventilates the patient with large breaths to help with the egress of gas. Once all gas is removed, back the trocar off the laparoscope. Then slowly back the laparoscope out of the trocar site to allow for inspection for bleeding and to prevent evisceration of abdominal content into the tract.
6. Irrigate all sites and inspect them for subcutaneous bleeding to prevent potential infection or hematoma formation. Close the skin and apply the dressing according to preference.

SUMMARY

Complications are an inevitable part of surgical practice. With experience, the overall risks of laparoscopic surgery are equivalent to those seen with open surgical approaches. Laparoscopic renal surgery has well-defined potential risks that need to be discussed in detail with patients. In order to prevent, recognize, and treat complications, the laparoscopist must be thoroughly versed in the potential pitfalls that exist from preoperative planning to laparoscopic exit. Experience and attention to detail can help keep complication rates and patient morbidity to a minimum.

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CHAPTER 29

Endoscopic Subcutaneous Modified Inguinal Lymph Node Dissection for Squamous Cell Carcinoma of the Penis

Jay T. Bishoff
Claudio Montiola

The presence and extent of metastatic disease to the lymph nodes are the most important prognostic indicators of survival in patients with squamous cell carcinoma of the penis. Lymphadenectomy is often required in this disease process for cancer staging and can also be curative when cancer is isolated to the penis and regional nodes.[1,2] Serious, life-altering complications have been associated with inguinal lymph node dissection. Due to the substantial morbidity caused from inguinal lymphadenectomy, controversy surrounds the utility of bilateral and prophylactic dissection.

In 2002, Dr. Ian M. Thompson conceived the idea of applying laparoscopic techniques in an endoscopic approach, with the hopes of decreasing the morbidity associated with open surgery, by preserving the continuity of the lymphatic and vascular supply to the overlying skin. Working together, we combined different techniques from subcutaneous endoscopic brow lift and saphenous vein harvest to formulate an approach using laparoscopic instruments for inguinal node dissection in staging penile cancer. The result of our work was the endoscopic subcutaneous modified inguinal lymphadenectomy (ESMIL) procedure, which mimics the same oncologic approach traditionally performed through an open incision.

We first explored the feasibility of this new procedure in several fresh cadaver studies; finally, in 2003 a patient with T3 N1 M0 squamous cell carcinoma of the penis underwent the first ESMIL procedure.[3] Since our initial report, another team of investigators has reported on the use of this procedure in the treatment and staging of penile cancers and has offered a new name—videoendoscopic radical inguinal lymphadenectomy, or VEIL—for the same procedure. Dr Machado and colleagues from Brazil used the endoscopic procedure on one leg and the open procedure on the opposite leg in three patients treated with bilateral inguinal lymph node dissection. They reported flap necrosis and lymphedema in two of three open sides but no complications, flap necrosis, or lymphedema in extremities treated with the endoscopic procedure.[4]

INDICATIONS AND CONTRAINDICATIONS

ESMIL is indicated when traditional inguinal lymphadenectomy would be required for staging squamous cell carcinoma of the penis. Patients with nonpalpable nodes or small (less than 1 cm) mobile nodes at high risk for inguinal node involvement are considered good candidates for endoscopic node dissection. Patients with pTa and pT1 grade 1 penile tumors have positive nodes approximately 10% of the time, when inguinal nodes are not enlarged. About 50% of patients with pT2 tumors and grade 3 tumors will demonstrate positive inguinal lymph nodes.

Both stage and grade are predictive of nodal involvement. Verrucous carcinoma and carcinoma in situ are both associated with a low risk for nodal metastasis. However, 70% of stage T2 cancers have positive nodes. Grade I tumors have a 30% chance of spread to lymph nodes, while approximately 85% of patients with grade III tumors have inguinal node involvement.[2] Because cross-drainage from the affected side to the contralateral side is a well-known occurrence, bilateral dissection is indicated in patients at high risk for metastatic disease (stage T2 or greater or grade II/III tumors).

Patients with large, fixed inguinal lymph nodes have a relative contraindication to ESMIL. In these patients, it can be very difficult to dissect the superior aspect of fixed, matted lymph nodes with an endoscopic technique and as a result are better candidates for traditional open surgery.

PATIENT PREOPERATIVE EVALUATION AND PREPARATION

Perform a complete metastatic evaluation before biopsy of the presenting penile lesion or partial penecotomy when indicated. Establish the presence of carcinoma of the penis with biopsy to

determine the diagnosis, extent of invasion, presence of vascular invasion, and grade of the lesion before lymphadenectomy. Distant metastatic disease without lymph node involvement is rarely seen. However, consider distant metastatic spread to bone, brain, liver, and lung as part of the overall workup for penile cancer. Computed tomography of the pelvis and inguinal region can be helpful in determining the presence of large pelvic and inguinal nodes, especially in the obese patient.

Fit and obtain waist-high elastic stockings for the patient before surgery. Give preoperative intravenous antibiotics for skin flora coverage 60 minutes before the skin incision. Perform a sterile prep of the area in the usual fashion.

OPERATING ROOM CONFIGURATION AND PATIENT POSITIONING

Configure the operating room so that all of the staff can view the procedure. The surgeon's monitor is placed on the contralateral side of the dissection, near the shoulder and arm of the patient. A second monitor is placed on the opposite side in the case of bilateral dissection or as needed for viewing by the entire team (Fig. 29–1).

Place the patient in a supine position, with the ipsilateral knee flexed and hip abducted. Secure the foot on the side of dissection to the contralateral leg in a unilateral dissection or secure both feet together in a bilateral procedure. Place a pad under the bent knee to help maintain the correct position during the case (Fig. 29–2).

TROCAR PLACEMENT

Before placing the first trocar, mark the limits of the dissection on the skin to preserve the orientation once the skin is distorted from the insufflation used to create the working space. Draw a line from the pubic tubercle to the anterior superior iliac crest. The width of the area of dissection is approximately 11 to 12 cm and the length 15 cm down the medial thigh and 20 cm on the lateral thigh (Fig. 29–3).

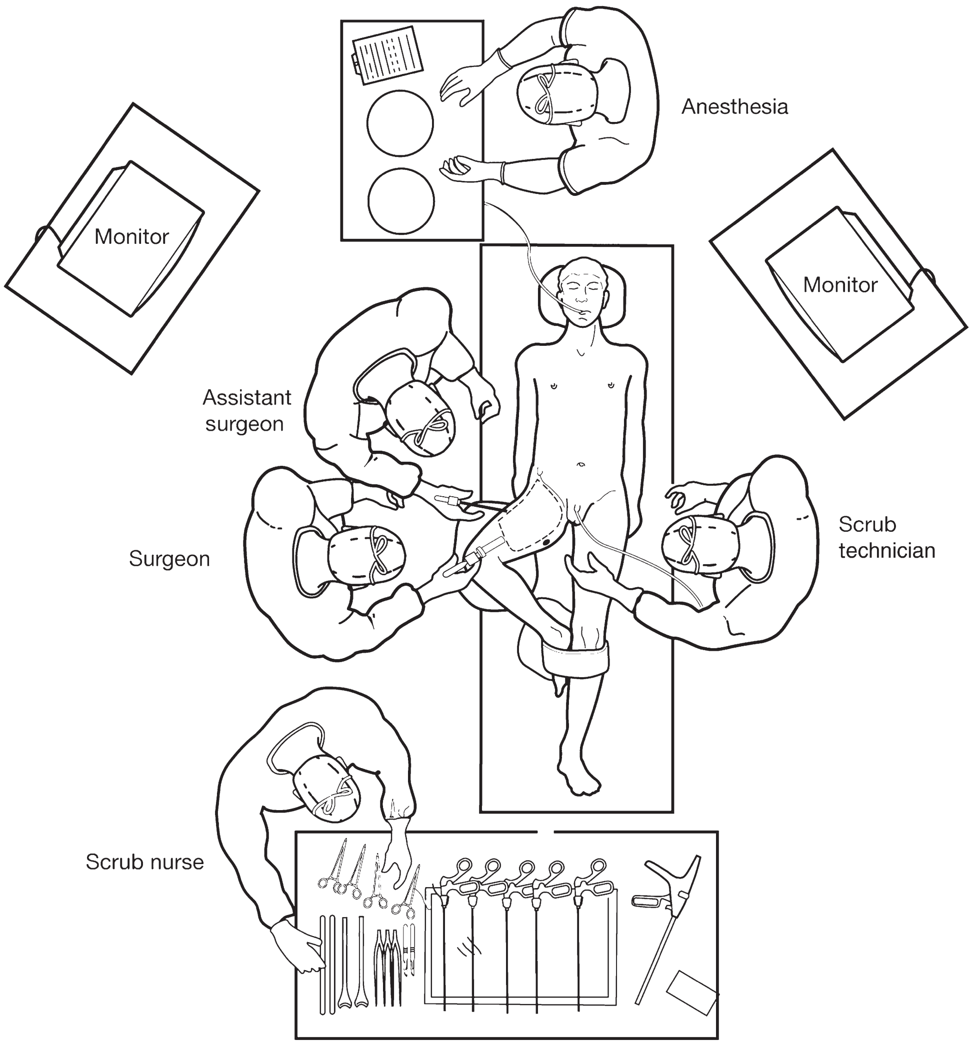

FIGURE 29–1. The operating room is configured so that all of the staff can view the procedure. The surgeon's monitor is placed on the contralateral side of the dissection, near the shoulder and arm of the patient. A second monitor is placed on the opposite side in the case of bilateral dissection or as needed for viewing by the entire team.

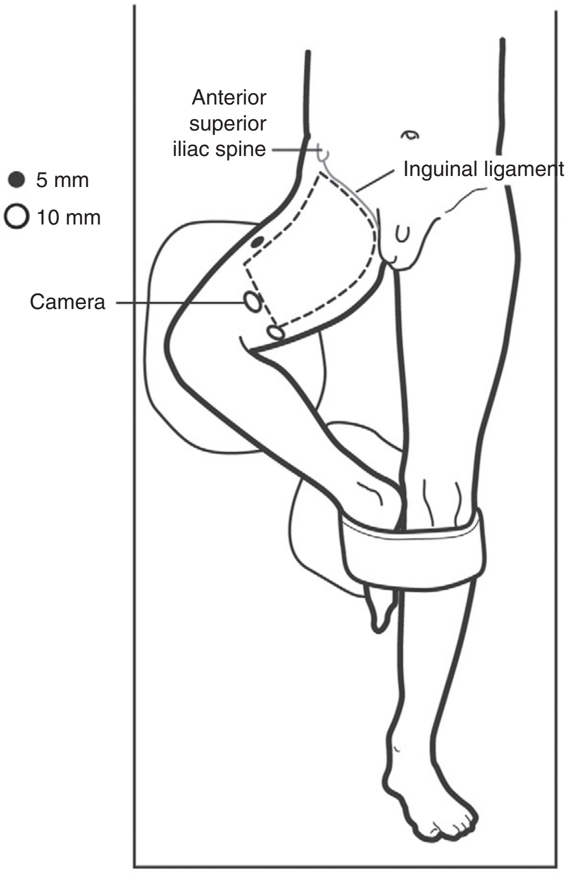

FIGURE 29–2. The patient is placed in a supine position, with the ipsilateral knee flexed and hip abducted. The foot on the side of dissection is secured to the contralateral leg in a unilateral dissection or both feet secured together in the case of a bilateral procedure. A pad placed under the bent knee will help maintain the correct position during the case.

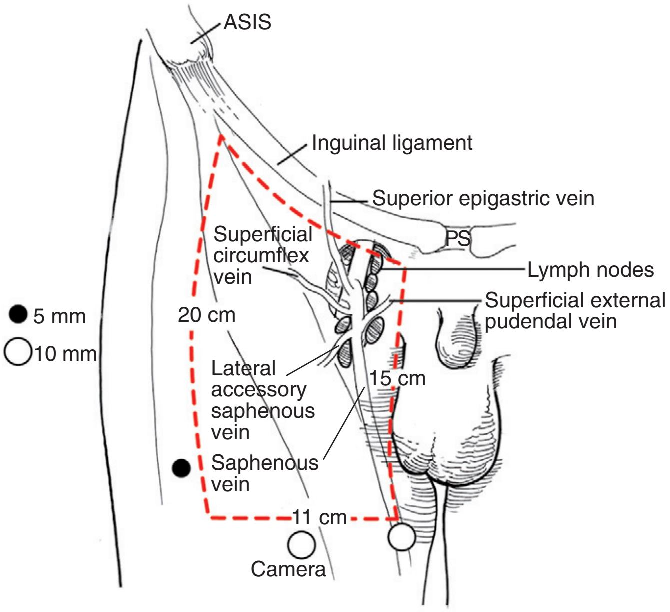

FIGURE 29–3. The limits of dissection are drawn on the skin. A line is drawn from the pubic tubercle to the anterior superior iliac crest. The width of the area of dissection is approximately 11 to 12 cm and the length 15 cm down the medial thigh and 20 cm on the lateral thigh. ASIS, anterior superior iliac spine.

Trocar placement is the same for the left and right sides. Place the trocars just outside the delineated area of dissection. Initially, place a 2.5-cm incision over the saphenous vein 15 cm below the pubic tubercle. Avoid making the incision any larger than 2.5 cm in order to prevent CO_2 escape during the procedure once the trocar is inserted and the subcutaneous cavity insufflated. Use sharp, fine scissors to develop the plane of dissection, elevating the skin from the deep membranous fascia and Scarpa's fascia toward the area of dissection drawn on the skin for as far as can be seen inside the lighted cavity. The laparoscope provides an excellent light source for the initial dissection. Place a Blunt Tip Trocar in the incision to create an airtight seal (U.S. Surgical, Norwalk, CT). The Blunt Tip Trocar is ideal for this procedure because its unique internal balloon and foam collar create an excellent seal and leave a very small profile inside the area of dissection. This trocar will become the medial working trocar, and because it is 10 mm, it can accommodate a retrieval bag to remove lymph node packets during the procedure. If a large nodal packet is placed in the bag and cannot be extracted through the trocar, the balloon on the trocar can be deflated and the packet (secured inside the retrieval bag) can be extracted directly through the incision. To prevent seeding the trocar site, do not extract fatty and lymphatic tissue specimens directly through the skin incision without placing them inside an extraction bag.

Place a second 2.5-cm incision outside the area of dissection approximately 16 cm inferior to the middle of the inguinal ligament. Use scissors to establish the correct plane of dissection toward the first trocar until the two planes of dissection are joined and a second Blunt Tip Trocar is placed. The laparoscope is usually placed through the second trocar during the procedure. Insufflate the working space to a pressure of 5 mm Hg.

Use a pair of endoscopic scissors or ultrasonic shears to dissect the inferior skin margin toward the edge of the surgical field so that the third trocar can be placed. Place a 5-mm threaded trocar outside the area of dissection approximately 15 cm below the iliac crest (Fig. 29–4).

PROCEDURE

Divide inguinal lymph nodes into superficial and deep nodes. The superficial nodes are those located anterior to the fascia lata and the deep nodes posterior to the fascia lata. Carry the inguinal lymph nodes dissection 2 cm above the inguinal ligament superiorly, laterally to the sartorius muscle and medially to the adductor longus. The superficial nodes are located in four quadrants centered around the saphenofemoral junction:

1. In the area of the superficial circumflex iliac vein
2. In the area of the superficial epigastric vein and the superficial external pudendal vein
3. In the inferomedial quadrant around the saphenous vein
4. Around the insertion of the superficial circumflex iliac vein and the lateral accessory saphenous vein[5] (Fig. 29–5)

The deep inguinal lymph nodes include the most cephalad node known as the node of Cloquet located in the area of the femoral vein and the lacunar ligament (Fig. 29–6).

The dissection begins above Scarpa's fascia anteriorly removing the tissue located between the skin and the fascia lata. Early

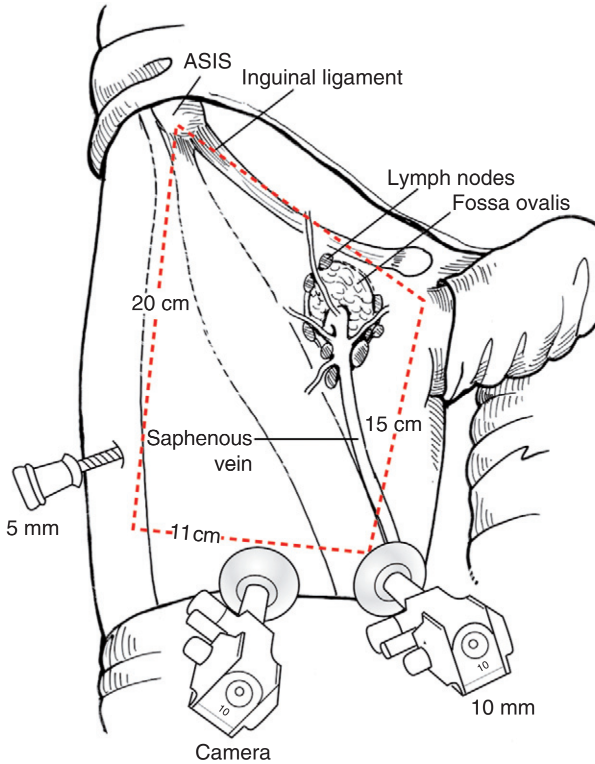

FIGURE 29–4. The trocars are placed just outside the delineated area of dissection. The first is placed approximately 15 cm below the pubic tubercle over the saphenous vein. A Blunt Tip Trocar is placed in the incision to create an airtight seal (Autosuture, U.S. Surgical, Norwalk, CT). A second 2.5-cm incision is placed outside the area of dissection approximately 16 cm inferior to the middle of the inguinal ligament, and a second Blunt Tip Trocar is placed. The laparoscope is usually placed through the second trocar during the procedure. A 5-mm threaded trocar is placed outside the area of dissection approximately 15 cm below the iliac crest.

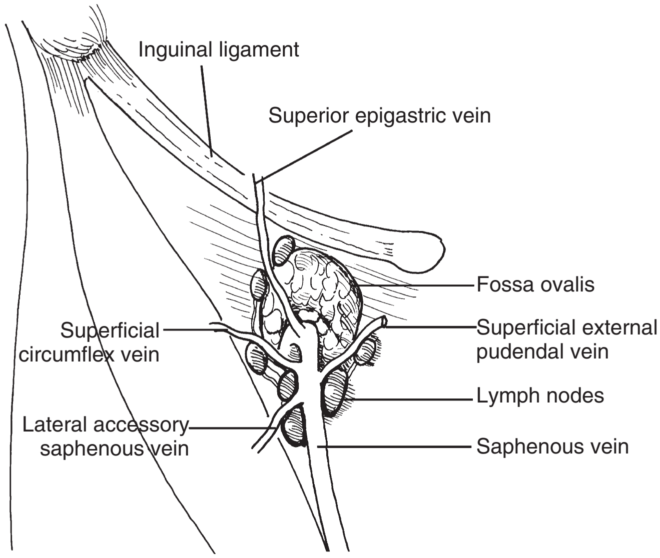

FIGURE 29–5. The superficial nodes are located in four quadrants centered around the saphenofemoral junction: (1) nodes in the area of the superficial circumflex iliac vein, (2) nodes in the area of the superficial epigastric vein and the superficial external pudendal vein, (3) nodes located in the inferomedial quadrant around the saphenous vein, and (4) nodes around the insertion of the superficial circumflex iliac vein and the lateral accessory saphenous vein.

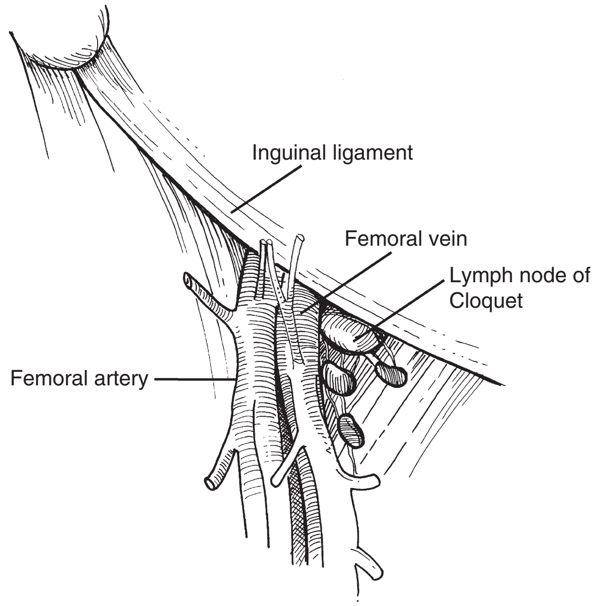

FIGURE 29–6. The deep inguinal lymph nodes are located under the fascia lata and include the most cephalad node known as the node of Cloquet located in the area of the femoral vein and the lacunar ligament.

in the dissection, identify and preserve the saphenous vein, if possible. It helps to identify the borders of dissection medially at the adductor longus and laterally at the sartorius muscle edges. In some patients, it can be difficult to identify these landmarks without opening the fascia lata, but the margins marked on the skin will help in the dissection of the superficial nodal tissue. Divide subcutaneous vessels and saphenous branches using ultrasonic energy or electrocautery. Dissect lymph node–bearing tissue from the fascia lata to the fossa ovalis.

As the dissection progresses toward the inguinal ligament, identify the external ring and remove the fat and lymphatics in the area of the cord to the base of the penis medially. Continue the lymph node dissection 3 to 4 cm superior to the inguinal ligament. Once the nodal tissue and fat are removed from the external oblique and the inguinal ligament, identify the femoral vessels inside the femoral sheath.

To gain access to the deep nodes, open the fascia lata to the edge of the adductor longus medially and the sartoris muscle laterally. Carefully remove the triangle-shaped lymph packet within the femoral triangle. Opening the femoral sheath down toward the apex of the triangle reveals the deep lymph nodes. Medial dissection frees the node of Cloquet. Remove any residual tissue between the femoral artery and vein. Take care to prevent injury to the femoral nerve by limiting the lateral dissection to the femoral artery.

If the skin overlying the exposed vessels seems compromised in any way, mobilize the sartorius from the anterior superior iliac crest using ultrasonic or bipolar cautery, and transfer it over the exposed vessels. Use three or four size 2-0 PDS sutures to attach the sartorius muscle to the inguinal ligament.

At the end of the procedure, place a 7-mm JP drain inside the cavity to ensure drainage at the most dependent site of dissection. Place this through either the 5-mm trocar site or a new site chosen as needed. Close the two 10-mm trocar sites with skin adhesive or subcuticular sutures. Once the skin adhesive

is dry, place a circular bandage around the surgical area and hold it in place with an elastic bandage for 24 hours.

POSTOPERATIVE MANAGEMENT

Waist-high elastic stockings are placed, and the patient is kept on bed rest for 5 to 7 days with the lower extremities elevated. Low-molecular-weight heparin or enoxaparin sodium (Lovenox) is started after surgery and continued until the patient is fully ambulatory. The subcutaneous drain remains in place until daily output is less than 30 mL.

COMPLICATIONS

Measure the diagnostic and therapeutic benefits of early inguinal lymphadenectomy against the potential morbidity associated with the procedure.[6,7] Patients must be aware of the minor and major postoperative complications associated with this procedure.

Minor postoperative complications include local wound debridement in clinics, mild-to-moderate leg edema, seroma formation not requiring aspiration, minimal skin edge necrosis requiring no therapy, and scrotal edema. Major complications include wound infection, severe leg edema interfering with ambulation, skin flap necrosis requiring skin graft, deep venous thrombosis, reexploration or other invasive procedure performed in the operating room, and death.

Tips and Tricks

- Use a lighted instrument or the light directed from the laparoscope to improve visualization of the initial dissection and establishment of the correct tissue planes during placement of the first two trocars.
- Facilitate dissection after placing trocars by entering the correct plane of dissection with scissors.
- Use continuous flow of CO_2 to allow rapid clearing of water vapor or smoke during dissection in the small working space.
- Use a working pressure of 5 mm Hg to maintain visualization while avoiding spontaneous infiltration beyond the boundaries of dissection.
- Readily identify key landmarks and transilluminate the skin to facilitate orientation.
- Follow the saphenous vein to help identify landmarks but preserve as many branches as possible to decrease lymphedema in the lower extremity.
- Divide all tissue with ultrasonic energy or electrocautery to decrease the incidence of lymphatic leak.

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